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World of Knowledge

ISSUE 32 NOVEMBER 2015
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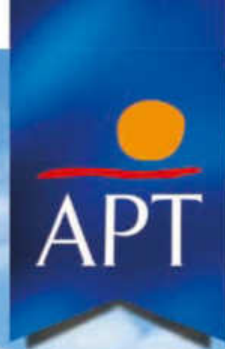


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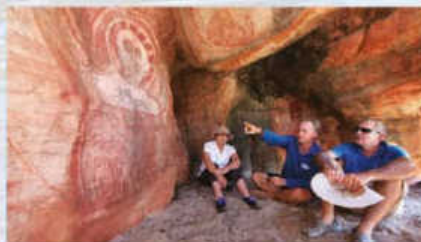


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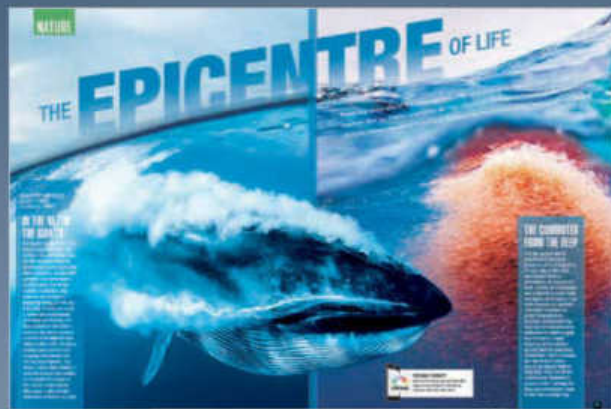
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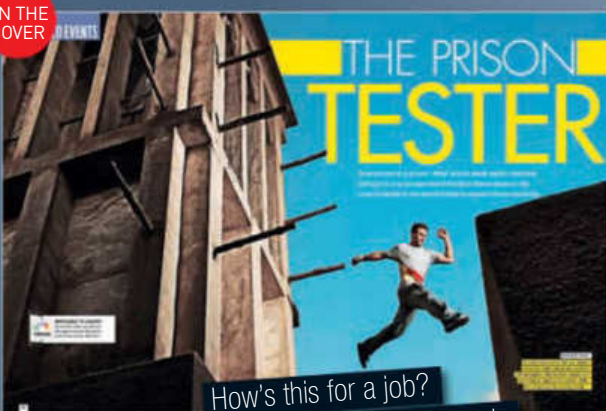


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PER CENT

of the land mass on Earth is desert. Think it's a dead world? Think again...

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WELCOME FROM THE EDITOR

Google 'Moon' and 'NASA', and chances are your scrolling finger won't even be warm before you're reading headers containing the words 'hoax', 'conspiracy' and, of course, 'aliens'. Delve deeper into the internet's bowels and you'll even find people willing to bet the house on the fact that our Moon is not even a moon, rather an artificial satellite cast into orbit by an ancient extraterrestrial civilisation. That silvery-white ball we see in the sky for certain parts of the month? The thing that dictates the tides, influences the axis of the Earth and affects both human and animal biology? Oh, that's just a hologram say the naysayers, you're all being hoodwinked.

Not all conspiracy theories are created equal. There's clearly a gulf in plausibility between, say, claims that pharmaceutical companies have a vested interest in keeping the population sick and the rumour about the Queen being a shape-shifting lizard. But by and large, in the corridors of *World Of Knowledge* we prefer to trade in solid facts, even when lounging on a conspiracy theory hotbed like the Moon. Which is what makes this month's cover story so fascinating. Who knew that Apollo astronauts had to get their own life insurance? Or that Buzz Aldrin performed a secret religious ceremony upon landing on the lunar surface? So enjoy the six real-life yarns we've dug up. And if you happen to spot a secret alien base in one of our photos... well, let us know. We'll try to keep an open mind.

Vince Jackson, Editor



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EXPERTS IN THIS ISSUE

>>94%

of all life
is found in
the oceans! <<

GRAHAM HAWKES

The marine researcher
The British underwater expert and
submarine designer has spent
almost half his life underwater.

PAGE 22



I SURVIVED EBOLA!

IAN CROZIER

Patient X
The American doctor
volunteered in Sierra
Leone and treated
countless Ebola
patients there – until
he became infected
with the deadly
disease himself.
Crozier agreed to an
extremely risky plan
to conquer the virus
once and for all.

PAGE 32

HUGO TESO

The attacker
The IT expert explains
how he can hack into a
virtual aeroplane using
a self-written app.

PAGE 78

"Modern
aeroplanes are
vulnerable to
hackers!"



DAN EDWARDES

Prison tester
The 39-year-old
founded Parkour
Generations, a
company that tests
jails for security flaws.

PAGE 62

"We're aware
of weak spots
in high-security
buildings."



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AMAZING PHOTO



MISSION IMPOSSIBLE

Chris Sharma is one of the world's top freeclimbers. The 34-year-old has mastered the toughest rock faces on the planet. His latest project, however, took him to the brink of despair: a redwood nearly 80 metres high

One of the greatest natural wonders on Earth was already standing here long before Columbus landed in America. Located in Eureka, California, the giant redwood on the left is more than 600 years old and 77 metres high. Preparing to climb it is Chris Sharma, an extreme climber who's unlikely to be daunted by such figures. The American has already mastered a variety of different climbs: barren cliff faces hundreds of metres high, arch-shaped limestone formations and routes with a difficulty rating of 9b+, the toughest in the world. So climbing this tree shouldn't really be a problem – until you learn that no human has ever taken on anything on this scale using just their bare hands. A short while later Sharma realises why: for the first 50 metres there are no branches to hold onto, while the bark is tricky to grip and can tear itself away from the trunk at any moment. Then there's the fact that the ascent route is impossible to plan...

"As rock climbers, we're trained to look at cliffs and see the sequence. On the redwood, I drew a blank. I got disoriented by all the patterns. There was definitely a very specific sequence," explains

Sharma. He'll have to embark upon the daring ascent without a map in his head – although he will have a safety rope. That's because his advisors, redwood expert Dr Anthony Ambrose and Wendy Baxter from the University of California, are concerned that the tree's bark won't be strong enough to hold his 76 kilogram bodyweight.

After three days of preparation Sharma begins his ascent. "The first 15 metres were really sustained," he recalls. "Good pinches and good footjams between the bark. Then the footholds ran out, and it was just pure compression moves with really precise footjams." About 30 metres up, the bark that Sharma is clinging onto rips. Without a secure line this would mean certain death. But Sharma battles back. He won't give up. The tree won't beat him. After several more scrapes and hours of climbing time he reaches the tree crown and gazes out at the breathtaking scenery of the Redwood National Park.

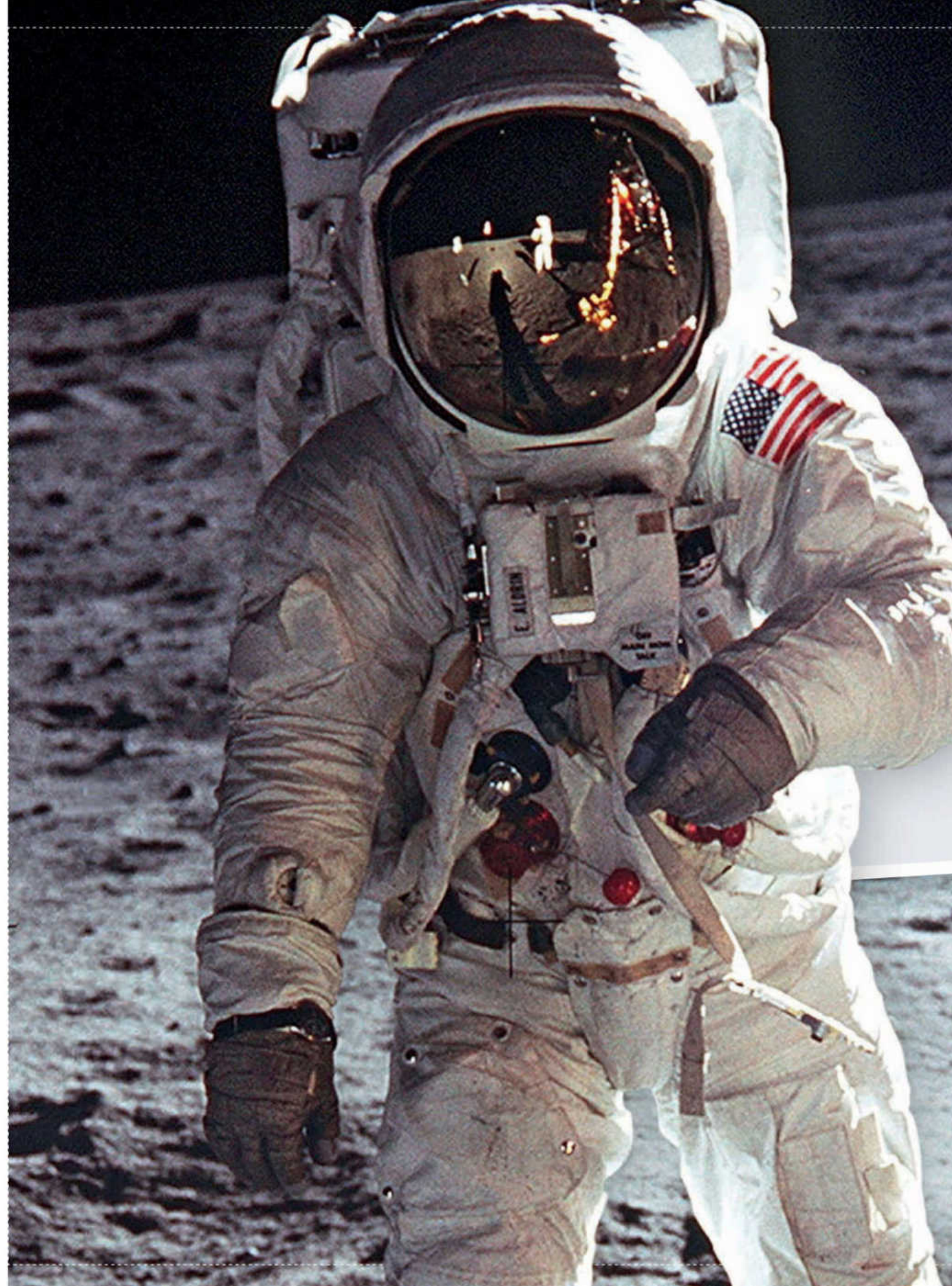
In the end Sharma wasn't able to 'redpoint' the route (complete it in one go after practising it), as he has successfully done in the past during other climbing attempts. But given the enormity of the challenge, it's still one hell of a climb. 

PHOTOS: Action Press (2)

BARKING MAD

No one has ever tried to scale a redwood with their bare hands before. The biggest uncertainty when climbing: will the bark hold Chris Sharma's 76kg bodyweight?





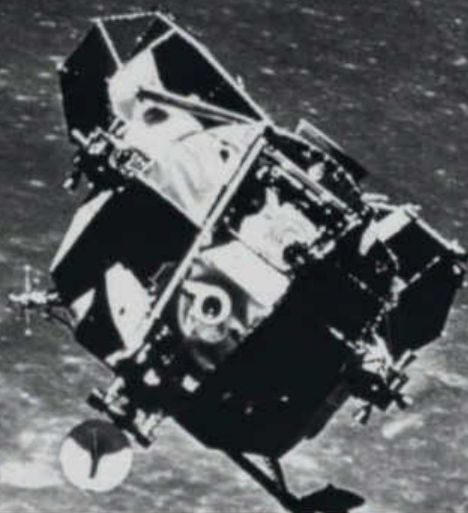
NASA'S MOON SECRETS

The Apollo missions were landmark events in history. But despite their high profile, some fascinating stories remain untold – either kept under wraps by America's space agency or diverted away from the public gaze

OFF TARGET

The Apollo module missed its original landing area because it was coming in too fast.

30 SECONDS
FROM DISASTER



WHAT RISKS DID NASA KEEP FROM THE PUBLIC?

W

hat we remember is the triumph and the wonder. What we don't realise is how close we came to remembering the date of July 20 as a tragic near-miss.

For those involved, the tension of the final few minutes before that magical touchdown was unbearable. Some almost mission-ending radio gremlins and the unidentified alarms that began ringing during the descent spooked the astronauts, but when pilot Neil Armstrong realised he'd missed the large, flat landing area they were meant to use, because they were coming in too fast, there was genuine panic.

"We would either land on the Moon, we would crash attempting to land, or we would abort," flight director Gene Kranz explained. "The final two outcomes were not good."

Fast running out of fuel, and faced with giant craters and boulders the size of trucks, Armstrong levelled off and searched for a safe spot to plant the lunar lander.

He was so low, and with less than 30 seconds left until a mandatory 'abort' call, that Mission

Control wasn't even sure an emergency firing of the ascent engine would work.

"It was an altitude [where] you just don't have enough time to do an abort before you had crashed ... Essentially, you're a dead man," as one NASA controller put it.

Still some three metres off the ground, Armstrong now found he could barely see through the dust and haze being created by the descent engine, but he somehow got it down.

Even then, a plug of ice in a fuel line prompted fears of an explosion on the Moon surface. Houston considered whether to tell the astronauts about the danger, and abandon the space walk, but the heat of the engines eventually melted the ice and removed the problem.

Incredibly, when Buzz Aldrin and Armstrong were allowed to open the lander's door, they couldn't because the air they'd tried to expel from the cabin wasn't purging properly.

History shows, of course, that the moonwalk all went swimmingly, but in fact it was just seconds, or one unfortunately placed boulder, from not happening at all.

WHY DID ASTRONAUTS GET THEIR OWN LIFE INSURANCE?

Sure, being an astronaut at the height of the Apollo missions would get you a seat in any restaurant, a free beer in any bar, or the company of the fairer sex, but the one thing it couldn't get you was life insurance.

It wouldn't take an actuary with a calculator very long to work out that people who sit on top of large explosive devices for a living are a bad risk to insure, yet the astronauts themselves were, understandably, worried about leaving their families financially in the lurch if any of their missions became one-way trips.

As a government employee, Neil Armstrong was only earning \$US17,000 a year, and, as an astronaut, life insurance would have cost him \$US50,000 annually (more than \$US300,000 in today's money), so a cunning plan was hatched.

When Armstrong, Buzz Aldrin and Michael Collins were locked in a quarantine room a couple of weeks before the Moon mission (NASA couldn't take the

chance of them catching a fever, or even a cold) they signed hundreds of what came to be known as Apollo Insurance Covers. These were envelopes emblazoned with their names, the details of their mission and some stylish space images. The kind of thing that would make a young collector salivate.

The slightly brutal idea was that these would become valuable mementoes should they perish in space, and the proceeds of selling them would go to their families. To make the envelopes even more desirable for collectors, the crew put stamps on them and sent them to a friend who would get them postmarked on July 16, 1969, regardless of their success or failure. It's hard to imagine how strangely morbid those autograph sessions must have been for the astronauts.

The Insurance Covers from all the Apollo missions are now highly coveted, but the Apollo 11 examples are the most valuable.



DID NAZI SCIENTISTS PUT MAN ON THE MOON?

Sitting smilingly at a desk decorated with rockets and backdropped by a stylised Moon-shot painting, he looks the very picture of an all-American NASA Space Flight Centre director.

But Wernher von Braun, a recognised hero of the Apollo program and its Moon shots, was an officer in the SS and responsible for the V-2 rocket that the Germans rained down upon innocent civilians in World War Two with tragic consequences.

A 'space cadet' from a young age, von Braun was hired by the German army in 1932, at just 20 years old, to work on its military rocket program.

What was to become the infamous V-2 ballistic missile was constructed in the early 1940s, using forced labour from concentration camps, thousands of whom were literally worked to death on the project.

Its first launch, in September 1944, changed the nature of warfare forever, firing death into foreign lands from as far as 700 kilometres away. The fact that these rockets would arrive without warning, and

that there was no defence against them, made them perhaps the first true weapons of terror. By the end of the war, 1,155 V-2 rockets had been launched into England alone.

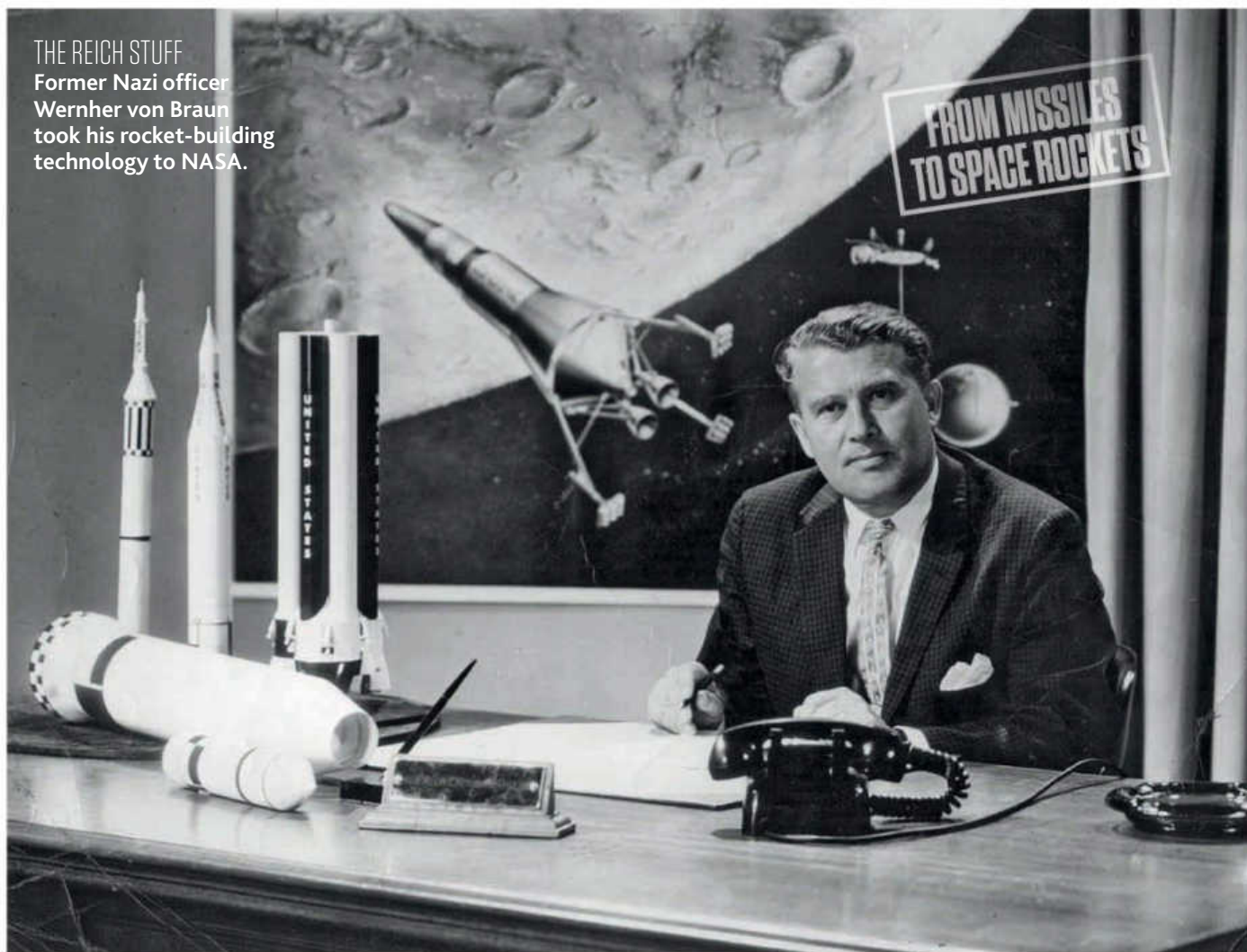
As World War Two drew to a close, von Braun surrendered to the Americans, offering to take his rocket-building crew, and his know-how, to the US. Using technology first developed on a ballistic missile designed to carry explosive warheads, he went on to become a leader of the team that built the Saturn V rocket that took man to the Moon.

Roger Launius from the Space History Division of the National Air and Space Museum in the US wrote that von Braun, who died in 1977, was a stunningly successful advocate for space exploration.

"For some he was a visionary who foresaw the potential of human spaceflight, but for others he was little more than an arms merchant who developed brutal weapons of mass destruction," says Launius. "In reality, he seems to have been something of both."

THE REICH STUFF

Former Nazi officer Wernher von Braun took his rocket-building technology to NASA.





HOLY CEREMONY
Astronaut Buzz Aldrin performed a secret communion upon landing on the Moon.



FIRST MOON LANDING!

Use the free viewa app and scan this page to re-live the historic moment from 1969. And more!

**FINDING GOD
ON THE MOON**

HOW DID NASA AVOID A RELIGIOUS CONTROVERSY?

America's televangelists may have changed the tone, but there was a time when the US was so worried about offending other countries with any overt Christianity that it banned the astronauts on Apollo 11 from engaging in any religious activities on the Moon.

Buzz Aldrin didn't like the memo, and decided to stow away a small plastic container containing wine and bread from the Webster Presbyterian church near Houston, where he was an elder.

Before he and Neil Armstrong stepped down those famous stairs, Aldrin radioed NASA and, he hoped, the world, and said: "I would like to request a few moments of silence ... and to invite each person listening in, wherever and whomever they may be, to pause for a moment and contemplate the events of the past few hours, and to give thanks in his or her own way."

Fearful of offending atheists, perhaps because it was being very publicly sued by one at the time, NASA never broadcast the message, but Aldrin did eat the blessed

bread and drink the wine out of a chalice he'd also snuck along with him (it's still in the Webster Presbyterian church today) and then read a section of gospel. Armstrong watched on, silently, without comment. "I poured the wine into the chalice our church had given me," Aldrin later wrote. "In the one-sixth gravity of the Moon the wine curled slowly and gracefully up the side of the cup. It was interesting to think that the very first liquid ever poured on the Moon, and the first food eaten there, were communion elements."

The story of Aldrin's secret communion only leaked out after the mission, and he has since indicated that if he had his time again, he wouldn't repeat his actions.

"Although it was a deeply meaningful experience for me, it was a Christian sacrament, and we had come to the Moon in the name of all mankind – be they Christians, Jews, Muslims, animists, agnostics, or atheists," Aldrin said. At his church, however, his communion service is still celebrated annually, in July, and is known as Lunar Communion Sunday.



ABORTED LUNAR
PROJECTS

ACCIDENT WARNING
NASA bosses feared that,
eventually, a fatal disaster
would befall one of the
Apollo missions.

WHAT HAPPENED TO NASA'S 'LOST' MOON MISSIONS?

M

oon-shot conspiracies are a feature of the internet age, and there's a seemingly endless supply of people out there willing to feed them.

In 2007, several videos were uploaded to YouTube claiming to contain footage of a secret joint American-Soviet space mission from 1976, called Apollo 20. Surprise, surprise, the project found aliens, according to the conspiracy theorists.

The *real* Apollo 20 was one of several Moon missions that were cancelled after the American public gave a kind of giant "been there, done that" sigh about space travel in general.

By 1968, 40 per cent of voters were in favour of cutting the space budget, but NASA had started cutting back well before that.

In January 1970, the Apollo 20 mission to the Moon was cancelled so that its Saturn V rocket could be used to launch the Skylab space station instead.

Both Apollo 18 and 19, scheduled for July and December 1973 were also canned in 1970 because of budget cuts, as people called for the money to be spent on other things, like eliminating poverty.

It has been reported that the bosses at NASA were

not entirely displeased by the decision to stop flights to the Moon, because they feared the whole program was so fraught with danger that a fatal accident would eventually happen if they continued.

All three of the cancelled Moon shots were dubbed 'J-series', meaning they were far more ambitious than earlier visits, with plans for the astronauts to stay on the surface for three days and make several moonwalks.

What we really missed out on, though, was the potential for scientific discoveries. All three missions were scheduled to visit large impact craters, with the hope being that they would recover ancient rock samples that had hit the lunar surface and remained unchanged since its earliest days.

That kind of primordial geology would have been uniquely useful in uncovering data about the early days of our solar system, or even the Big Bang itself.

There were other Moon missions that were canned, but those were planned behind the Iron Curtain. After the USSR lost the race to the lunar surface, it tore up its plans for a Moon shot, despite nine cosmonauts having already been trained for the job. If things had gone differently, the first words spoken on the Moon might well have been in Russian.



WHAT IF THE APOLLO 11 ASTRONAUTS HAD DIED?

Even once Armstrong and Aldrin had landed and walked on the Moon, the people behind the project, and even then-US President Richard Nixon, were preparing to deal with the fallout from their imminent deaths.

A memo entitled 'In Event of Moon Disaster' had been drawn up by the White House after astronaut Frank Borman, the Apollo 8 commander, contacted Nixon's senior speech writer, William Safire, and advised him to prepare "some alternative posture for the president, in the event of mishaps".

Safire wasn't clear what he meant until he added: "Like what to do for the widows."

Even as the president congratulated the astronauts, using what now looks like a very retro telephone, NASA staff knew full well that the most perilous part of the mission was still to come.

Getting Aldrin and Armstrong off the lunar surface was fraught with danger, and not only because they were worried about the ascent engine firing, or a failure to dock properly with the orbiting command module (piloted by Michael Collins) sending them spinning into outer space forever. There was also a genuine fear that the lunar dust on their spacesuits

would spontaneously combust as soon as it contacted oxygen inside the lunar module.

Safire later admitted that he felt like preparing the contingency plans was a harbinger of bad luck, but he delivered his proposed doomsday speech anyway. The plan was for Nixon to telephone "each of the widows-to-be" and then address the nation to eulogise them.

"Fate has ordained that the men who went to the Moon to explore in peace will stay on the Moon to rest in peace," Nixon would say.

"These two men are laying down their lives in mankind's most noble goal: the search for truth and understanding.

"In ancient days, men looked at stars and saw their heroes in the constellations. In modern times, we do much the same, but our heroes are epic men of flesh and blood.

"Others will follow, and surely find their way home. Man's search will not be denied. But these men were the first, and they will remain the foremost in our hearts.

"For every human being who looks up at the Moon in the nights to come will know that there is some corner of another world that is forever mankind." **W**

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NATURE

THE EPICENTER

GULF OF MEXICO

Latitude **N24°**

Longitude **W97°**

IN THE NET OF THE GIANTS

The Bryde's whale [left] can dive to depths of up to 300 metres – but the things that the 26-ton giant needs to survive are found right at the water's surface: oxygen and nutrition. The whale has to surface every five to ten minutes to breathe, and needs to get through a whopping 660kg of krill and fish a day. It does this using a clever technique known as bubble net feeding. If it finds a shoal at the water's surface, the whale releases a series of air bubbles that function like a net: the dense bubbles surround the krill, trapping them inside and forcing them upward. The Bryde's whale then thunders upwards through the bubble net towards the school of fish, its six-metre mouth wide open – and catches thousands of fish in one gulp.

TRE OF LIFE

From the deep sea to the troposphere – life on Earth stretches out over 20,000 metres. But no region is as vital, as rich in species and as contested as the few metres directly below the water's surface. Behold the most fascinating habitat on our planet

THE COMMUTER FROM THE DEEP

It is the largest animal migration in the world. Known as vertical migration, it's also one of the most spectacular natural phenomena. As soon as it's dark, billions of crustaceans and small fish emerge from the depths of the ocean and swim towards the nutrient-rich water's surface to gorge themselves on plankton. At daybreak the majority of them dive back down into the depths again. Any creatures caught lingering at the surface quickly become easy prey themselves. That's because, like the Bryde's whale, almost all whales feed on fatty krill. They cut off the crustaceans' downwards escape route – turning the deep sea commuters' zone of life into a deadly trap.



FEEDING FRENZY!

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**BONAIRE,
CARIBBEAN SEA**
Latitude **N12°**
Longitude **W68°**

SATISFIED HEAVYWEIGHT

Depending on their habitat, pelicans use a whole raft of different hunting techniques: nose-diving under the water, employing a hit-and-miss shovelling technique, or even hunting in a team. Regardless of the method used, though, all of them hunt from directly beneath the water's surface – because with a bodyweight of up to 13kg, they're pretty poor divers. After scooping up prey in its bill, the pelican contracts its pouch to expel any excess water. Then it jerks its head back, sending the fish sliding down the hatch. After a particularly filling meal, pelicans have to stay at the surface, because the added weight of the food means they're no longer in a position to take off. That's why it's not uncommon to see pelicans sitting idly in the water for hours on end, surrounded by schools of fish.

A polar bear is shown swimming in the water, with its head and front paws visible above the surface. The bear is looking upwards, and its white fur contrasts with the dark blue water. The background is a clear blue sky.

HUDSON BAY, CANADA

Latitude **N70°**

Longitude **W81°**

GOOD THINGS COME TO THOSE WHO WAIT

Officially the polar bear is considered the biggest land predator on Earth. In reality, however, the 3.5-metre-tall Arctic giant draws almost all of its nutrition from the water – or, more precisely, from a few metres below the ocean's surface. Seals, walruses, beluga whales – the polar bear knows instinctively that all of its prey must surface to breathe. What's more, it can smell its prey even through layers of ice several metres thick. And so it positions itself patiently by a hole in the ice and simply grabs its prey as soon as it surfaces. For seals and whales under the water, the bear is practically invisible because its white fur coat means it blends into the landscape of the ice desert.



**BORA BORA,
SOUTH PACIFIC**
Latitude **S16°**
Longitude **W151°**

Magnificent flying machines

Admittedly, many rays spend the majority of their lives on the seabed, buried in sand, lying in wait for crabs. The manta ray, however, has plumped for a different habitat – the water's surface. The seven-metre giant likes to hang out here as it can Hoover up kilos of tasty krill in its two-metre-wide mouth. And if that wasn't reason enough, the surface is also where the manta can really show off its swagger. Experts have observed how male manta rays catapult themselves up to four metres out of the water and perform a somersault before rounding off the acrobatics with a cracking belly flop. This gives the flying acrobat the best chance with the ladies. Needless to say it's also much more fun than lying around on a gloomy sea floor.

**MALDIVES,
INDIAN OCEAN**

Latitude **N2°**
Longitude **E73°**

The perfect hiding place

Sea turtles like these loggerheads travel more than 11,200 kilometres over the course of their lives. In the process they almost always remain within ten metres of the water's surface. Their preference for a light-flooded habitat comes down to three things. 1. They need to breathe every five minutes so it doesn't make much sense for them to hang around in the depths – especially since they can't see anything down there either. 2. On the warm surface, rafts of algae the size of football pitches provide young sea turtles with the perfect hiding place from predators. 3. During their long journeys sea turtles rely on the position of the sun as well as magnetic fields to navigate – so the nearer they are to the surface the better.



FLORIDA,
CARIBBEAN SEA

Latitude N25°
Longitude W81°

Half a ton of laziness

Warm, 20-degree water, hardly any current, up to 100kg of sea grass per day – it's not surprising that Caribbean manatees spend their entire lives in extremely shallow waters. The 500kg animals don't need to dive far or for very long to find food – everything they need is right in front of their snout. And they have no natural predators to fear in the turquoise blue lagoon like they would in the open sea. The only thing that poses a danger to the lumbering goliaths? In the past 100 years another living creature has discovered the water's surface in the Caribbean – the human. As a result, every year dozens of manatees are injured by motorboat propellers.





ROSS SEA, ANTARCTIC

Latitude **S78°**

Longitude **W164°**

Behind enemy lines

Emperor penguins cover up to 560 kilometres in the search for fish and krill. The creatures instinctively know that the most perilous part of their journey is the few seconds they spend diving in and out of the water. That's because here – just a few metres under the ice sheet – is where their deadliest enemy lurks: the leopard seal. To escape them, penguins accelerate to 25km/h once under water and shoot through these enemy lines like torpedoes. The trick? The penguins release air through their plumage in the form of thousands of micro-bubbles. These create a lubrication layer that reduces drag, enabling the penguin to swim faster. It also has the added advantage of disturbing the vision of any lurking leopard seals.



The world wonder begins at sunset – and is repeated every night. It plays havoc with the sonar of passing ships and until a few years ago had barely been researched. What are we describing? So-called vertical migration, by far the biggest animal migration on the planet. It affects trillions of ocean dwellers all over the Pacific, the Indian Ocean and the Atlantic. As soon as the sun goes down they begin to rise hundreds of metres from the deep sea towards the surface. They're all aiming for the same place: the epipelagic zone – the uppermost part of the ocean,

where two worlds meet and where a mere flap of the fin decides between life and death.

Oceanographer Daniele Bianchi checks his instruments. He looks stunned. In the space of a few short minutes the movement of water in the ocean beneath his boat has increased 10,000 fold. Not as a result of currents or winds, but due to billions of tiny crustaceans and fish larvae floating up from the depths. Together with billions of other sea dwellers, they churn through the water in the oceans. Then, just a few hours later when the first rays of sunlight penetrate the water's surface, the commuters from the underworld dive back down

into the depths of the ocean again. The unbelievable thing is that this spectacular natural phenomenon takes place in all of the world's oceans, irrespective of climate, water temperature and salinity levels.

But what drives the animals to such vertical mass migration? Why does the very top of the epipelagic zone, the few metres just below the surface, act like a magnet for billions of sea creatures? And under what conditions does this habitat transform itself into the biggest battlefield in the world?

"Ninety-four percent of all life on our planet is found in the oceans," explains marine researcher Graham Hawkes. The unbelievable thing



about this is that although the oceans are up to 10,000 metres deep, 98% of all marine species spend most of their lives in the 20 metres immediately below the water's surface. The reason for that? A letter and a number – O₂, oxygen. At the light-flooded water's surface the concentration of oxygen is approximately 5-10 millilitres per litre. But this decreases the further down you go. Depending on the region this happens at differing speeds. "Off the coast of Peru the oxygen content at a depth of 10-15 metres is basically zero," says oceanographer Lothar Stramma. What lies below it is what marine biologists call an Oxygen Minimum Zone (OMZ), also known as a dead zone. Although crustaceans and microorganisms are able to survive here, there's very little food available in comparison to the water's surface. Hence their daily commute.

Most large sea dwellers (with the exception of squid, octopuses and sperm whales) spend nearly 24 hours a day in the few metres just below the water's surface. Because where there's oxygen, there's nutrient-rich phytoplankton – and where there's food, there are vast shoals of fish. These in turn draw in rays, sharks, dolphins, whales – and even birds. It's a domino effect that makes this zone one of the most hotly contested habitats in the world.

A black shadow at the tip of South Africa, 16-kilometres long and nearly a mile wide: it's the biggest swarm in the world. Billions of sardines have congregated here where, in July, the Benguela current carries

with it oxygen-rich water from the Antarctic. They're here because sardines need a lot of oxygen and the Benguela contains twice as much on the water's surface as the warm waters of the Indian Ocean do.

The first to track down the vast school of fish are dolphins – using echolocation. Soon there are more than 20,000 of the animals, followed by representatives of dozens of shark species, as well as humpback, Bryde's and minke whales, all watched over by hundreds of thousands of sea birds. But how will they open the hunt on this gigantic, impenetrable-looking wall of fish?

We don't have to wait long for an

'A FEEDING FRENZY DEVELOPS AS THE DOLPHINS SHOOT THROUGH THE BALL'

answer. Large schools comprising dozens of dolphins swim directly at the mega-swarm, separating small pockets of 25cm-long sardines from the main group and pushing them out into the open sea. "And now the sardines fall victim to the very thing that previously protected them on their journey," says professional diver and oceanographer Marc Addison. "That's because the fish can perceive the movements of the dolphins with their sense organs and instinctively seek protection in new, smaller swarms. What we're left with

is a so-called bait ball." A ball the size of a lorry, comprising millions of fish, which now attracts sharks as well as barracudas, tuna and many other large predators.

A feeding frenzy develops as the predators shoot through the ball. The dolphins continue to circle the swarm, drawing ever closer, driving the fish further and further towards the surface so that the swarm becomes more and more dense. "The sardines are now under massive stress. The flight reflex is activated in their bodies so their muscles require more oxygen than before," says Addison. But the oxygen reserves in the water are limited. In the Benguela the level is more than 13 milligrams per litre. "Near the bait ball, however, that sinks closer to zero," explains Addison. A death zone similar to the area near the summit of Everest. And just like high-altitude mountaineering, "artificial" oxygen is also now required to survive for longer here – or even to hunt.

Hundreds of sea birds swoop down onto the water's surface, snapping up as many fish as they can carry.

Dolphins too are in their element now. Lungs filled with fresh sea air, they shred the swarm in minutes – until all that's left of the 50 tons of sardines in the bait ball is billions of tiny fish scales that sink into the depths like glimmering silver snowflakes. They're the only traces of a battle that has taken place millions of times before in all of the world's oceans, one which begins just a few centimetres below the water's surface. **W**

HUMAN BODY

The patient's results are clear – and there's nothing Dr Ian Crozier can do for him. A few hours after the first symptoms appeared, his fever worsens. Like a tsunami, the Ebola virus spreads through the infected man's body. His heartbeat gets weaker and weaker, while his lungs, liver and kidneys start to shut down. "The progression chart was terrifying" recalls Dr Crozier. The thing that disturbed the doctor most of all? "The patient was me..."

**“ I SURVIVED
EBOLA ”**

ANATOMY OF A KILLER

0.0014 centimetres long, a thousand times thinner than a human hair and with a fatality rate of up to 90%: this 3D model shows the makeup of Ebola, one of the most aggressive viruses in the world. But what happens in the human body when it is infected? Millions of the thread-shaped killers invade the cells, transforming every one of them into a virus factory. The immune system reacts with a high temperature – but is normally disabled by the virus. The invaders eat away at the cell walls of the organs. By the end the only thing remaining is often the skeleton of the virus. In Africa, people are still dying from the virus.

MATRIX LAYER

The Ebola virus particle contains a matrix layer that is located under the viral membrane. It disables the immune system of the infected person and contains proteins which help to form the structural shell of a new virus particle, a process known as 'viral budding'.

DEADLY GENE

The Ebola genome is coiled in the virus's nucleus as an RNA strand and wrapped in protein molecules.

DOCKING STATION

The outer shell is strewn with anchors, so-called glycoproteins, which allow the virus to dock onto host cells.

W

hen American doctor Ian Crozier touches down in Sierra Leone in August 2014, the Ebola virus is already out of control. Crozier is there to volunteer at the Kenema Government Hospital in the east of the country. Every day the hospital admits between 60 and 80 newly-infected patients. Many die within hours, others battle on for days against the deadly virus. A choking, rotting smell hangs heavy in the humid air. The hospital's crowded corridors are a cacophony of noise, as screams of pain mingle with

cries for help and muttered prayers. It is the soundtrack from the heart of darkness. In his blue protective suit Crozier feels like an extra-terrestrial among zombies – until he becomes one of them.

"IN AFRICA I WOULDN'T EVEN HAVE LASTED SEVEN DAYS."

On 6th September 2014 Dr Crozier wakes up in his hotel with a splitting headache. A thermometer shows he's running a fever of 38.5 degrees Celsius. Hoping it is just malaria, he shuts himself in his room and rings a colleague who collects a blood sample from him.

The next morning the diagnosis arrives: Crozier has been infected with Ebola. How has the 44-year-old caught the virus? Even today nobody's quite sure. But one thing is for certain: depending on treatment and the progression of the disease, the fatality rate can be up to 90%. "In spite of this I felt no panic," Crozier recalls. "As a doctor,



I was more occupied in observing how the virus changed my body."

Two days after his diagnosis the medic was flown back to the US on a specially equipped plane. "If I'd stayed in Africa, I wouldn't even have lasted seven days," says Crozier. The virus had already begun reprogramming the blood cells in his body. Internal bleeding began to spread, destroying his organs. "By this point I was already in a state of delirium." By the time he arrived at Emory University Hospital

RISKY TRANSPORTATION

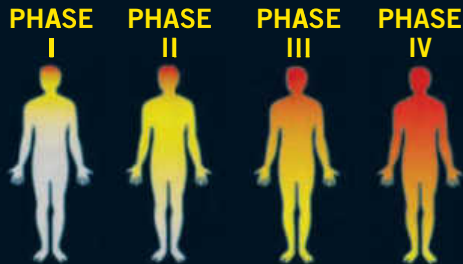
A special stretcher is used to transport a highly contagious Ebola-infected patient into Emory University Hospital in Atlanta after his flight from West Africa.



COUNTDOWN TO COMPLETE SYSTEM COLLAPSE

“What AIDS achieves in ten years, Ebola manages in ten days,” explains Ebola expert Richard Preston. The virus is one of the most aggressive in the world and

paralyses the entire immune system in just a few days – it literally eats its way through the body. The symptoms unleashed by this cell destruction are shown here...



DAY 7 Once the victim has been infected with the virus, flu-like symptoms are first to appear.

DAY 9 Temperature rises rapidly, the victim is barely able to move.

DAY 11 Internal bleeding in the stomach, gut and genital region.

DAY 13 Loss of consciousness, organ failure due to cell destruction.

SKIN RASH

As a result of the damaged cell walls bleeding and extreme skin rashes arise.

VOMITING

Nausea, diarrhoea, vomiting – the body reacts with intense defensive mechanisms.

MUSCLE PAIN

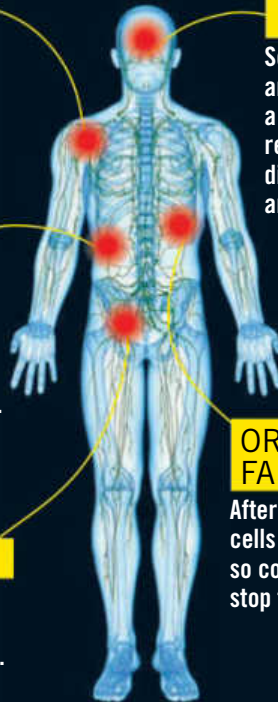
The muscles and joints feel stiff. Every movement causes pain.

HAMMERING IN THE HEAD

Severe headaches are accompanied by a fever, chills, reddened eyes and difficulty swallowing and breathing.

ORGAN FAILURE

After a few days the cells of the organs are so corroded that they stop functioning.



in Atlanta, Crozier had lost consciousness. Even today he has no recollection of the three weeks he spent there – but the team of doctors do.

“HE WAS BY FAR THE SICKEST PATIENT WE’VE TREATED WHO WENT ON TO SURVIVE.”

Even for the experienced virologist at the Ebola Isolation Unit, Dr Jay Varkey, the blood analysis is a shock: “The viral load, that’s the amount of Ebola viruses in Crozier’s blood, was 100 times higher than in any other Ebola patient we’ve treated here.” No one had ever survived such an extreme state of infection. In the following days 20 billion Ebola viruses attack Crozier’s brain and kidneys. He’s given dialysis treatment to prevent his kidneys from collapsing. When his lungs also fail, he is hooked up to

a respirator. This is the moment when his relatives, only able to look on helplessly through a thick glass wall, begin to lose hope: “It looked very much like these were his final hours. We worried that we wouldn’t be able to touch him one last time before he was cremated,” his mother recalls. That’s because Ebola victims remain contagious for several days after death.

“Basically, Crozier’s immune system was wiped out, finished. His white blood cells had lost the fight against the aggressive invaders,” says Bruce Ribner, who heads the isolation unit at Emory Hospital. But instead of throwing in the towel, the doctors pin their hopes on one man: British nurse and former Ebola patient Will Pooley.

Pooley, the first Briton to contract the virus, was granted an emergency passport to travel

to Atlanta. Like Crozier, he’d contracted Ebola in Sierra Leone. But unlike him, he had successfully fought and survived the virus. As a result his body had developed millions of antibodies against Ebola. And it was these that were transfused into the body of Ian Crozier in the form of a blood plasma donation. It was a strategy that made an impact.

“SUDDENLY MY EYES CHANGED COLOUR.”

As the days pass Crozier’s blood values begin to improve and the level of the virus sinks rapidly. The doctor finally leaves hospital on 9th October 2014 after 24 days on dialysis, 12 days on a respirator and a total of 33 days fighting for his life. Fifteen kilograms lighter than when he was admitted, he’s given the all-clear. A devastating

misdiagnosis, as came to light just two months later.

Eight weeks after leaving hospital Crozier feels a mounting pressure in his left eye. With every passing day his vision deteriorates; worn down by the pain, he returns to Emory University Hospital. At first doctors suspect an infection. They pierce his eye with a hair-thin needle, draw fluid from its inner chamber and send it to the lab. The results are a terrible shock: the inside of the eye is teeming with Ebola viruses. Although his blood was completely free of Ebola when he was discharged, it appears that millions of virus copies withdrew to his eye – and survived there. Doctors believe the reason behind this is the eye's 'immune privilege': the inside

of the eye is cut off from the immune system, making it the perfect hiding place for the Ebola viruses. And that's not all: they're multiplying every day.

"The condition of my health deteriorated rapidly. Not just my eyes – my muscles ached, I felt weak and could no longer hear with my left ear. The left side of my life was missing," remembers Crozier. Ten days later, the colour of his left eye changes from blue to green overnight. "It was both unsettling and fascinating at the same time," he says. In consultation with Crozier the specialists decide on a risky plan – and break new medical ground: with special dispensation from US authorities, doctors administer an antiviral drug that



is still being tested. At first the pills – doctors are unwilling to divulge their actual name – had no effect, but a few days later the colour of Crozier's eye changes back from green to blue, and the colony of viruses in his eye is destroyed.

Whether down to the drug or just pure luck is still unclear. But the fact is the virus was completely eliminated. Unfortunately, that doesn't mean that Ebola hasn't left behind any traces in Crozier's body. "I am no longer the same person as before. I can't run very fast, I get tired easily and an MRI scan showed many small holes in my brain," says Crozier. And yet the disease has also had a positive effect: in the fight against the virus, extremely high levels of antibodies have developed in Crozier's body and remain there, making him – like Pooley and other Ebola survivors – almost certainly immune to the virus. It is highly unlikely that they could be infected again.

Crozier wants to take advantage of his immunity and fly back to West Africa, where thousands of people are suffering from what's being called 'post-Ebola syndrome'. Characterised by vision loss and long-term poor health, little research has been done into the causes for this. Crozier wants to unlock them – and the best place to do so is the very place where his own incredible story of suffering began. **W**

Can Ebola viruses hide?

Two months after Ian Crozier was discharged from hospital, the 44-year-old suddenly felt a sharp pain in his left eye. His eye colour even changed – from blue to green. Doctors made a shocking discovery: during treatment the Ebola virus had retreated unnoticed into his eye, where it continued to multiply. A special therapy eventually saved Crozier's eyesight and eliminated the Ebola virus from his body.



GUINEA PIG

Crozier received a medical treatment that has not yet been approved – it took effect immediately and destroyed the viruses.



SMARTER IN 60 SECONDS...

4 FASCINATING QUESTIONS ABOUT VIRUSES

WHICH VIRUS CLAIMED THE MOST LIVES?



The 20th and 21st century saw some of the most deadly virus pandemics. The Spanish flu was particularly devastating. From 1918 it killed more than 25 million people – some experts believe the figure may even be closer to 50 million. By way of comparison, around 1.5 million people die from AIDS-related illnesses every year, while malaria kills more than 600,000. The recent Ebola epidemic has claimed more than 11,000 lives since December 2013.



DOES THE SEASON DETERMINE WHICH VIRUSES ARE CIRCULATING?



The symptoms are similar, but the viruses that cause them are entirely different. “During the summer, enteroviruses, coxsackieviruses and echoviruses are mainly responsible for flu-like illnesses,” explains virologist Dr Joerg Hofmann. In winter, on the other hand, rhinoviruses and coronaviruses are to blame. Both infections can cause head, throat and earache alongside a cough, runny nose and a fever. Occasionally gastric symptoms can appear in combination with the summer flu.

INVASION

Rhino- and coronaviruses [illustrated] infiltrate our mucosal membranes and cause colds.



Can viruses fight cancer?



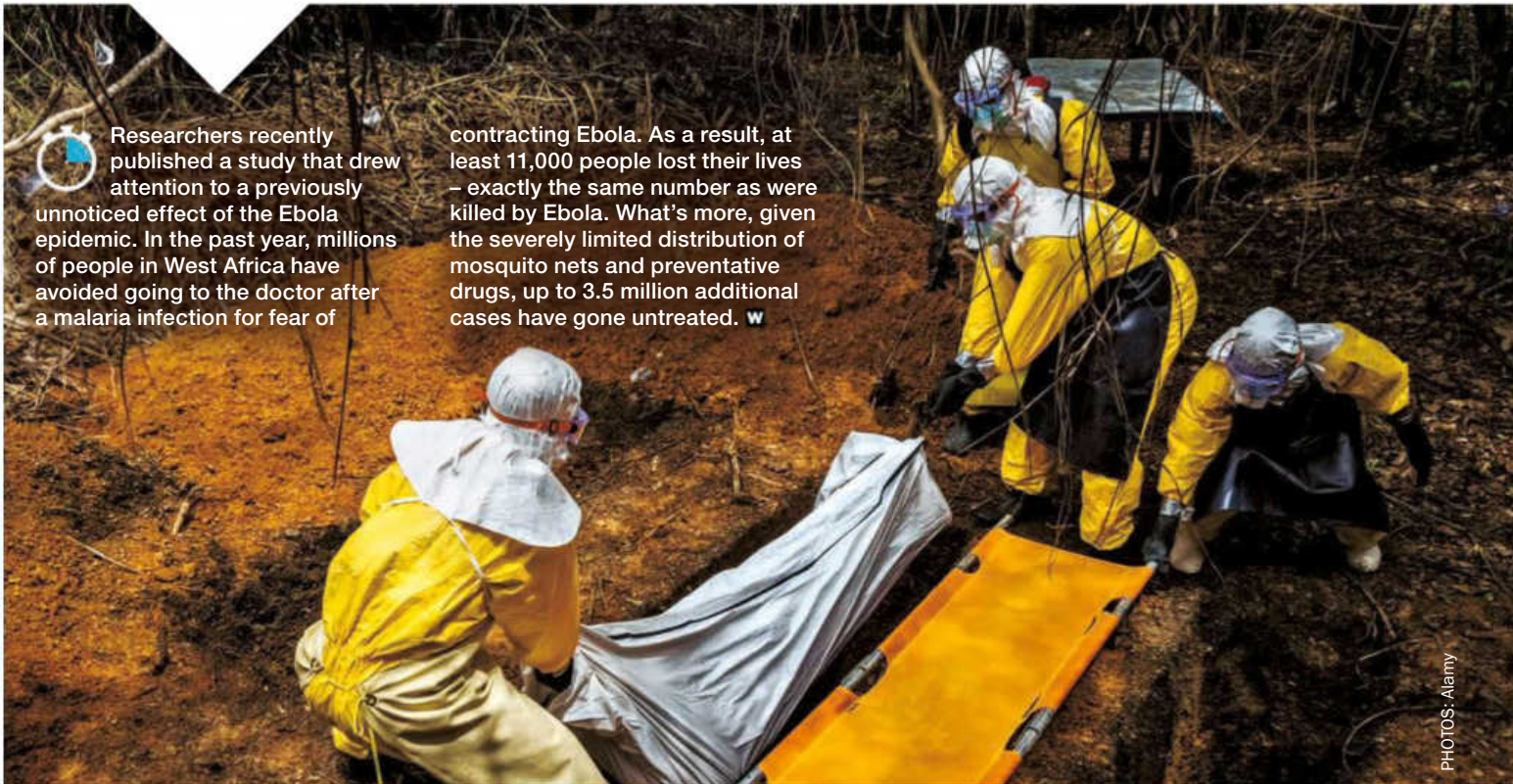
Cancer researcher Guy Ungerechts has succeeded for the first time in reprogramming the measles virus from a vaccine strain so that it attacks cancer cells. The virus recognises receptors that are particularly common among cancer cells. It attaches itself to these, multiplies and triggers a kind of ‘suicide software’ in the cancerous cells. At the same time the measles virus forces the infected cells to release a chemical messenger that sounds the alarm to the immune system. “It supports the virus and also begins to fight the cancer cells that the virus hasn’t killed off,” explains Ungerechts. This approach is known as immunovirotherapy – and has already proved successful in tests on mice.

HOW MANY PEOPLE DIED AS A RESULT OF EBOLA WITHOUT EVEN BEING INFECTED?



Researchers recently published a study that drew attention to a previously unnoticed effect of the Ebola epidemic. In the past year, millions of people in West Africa have avoided going to the doctor after a malaria infection for fear of

contracting Ebola. As a result, at least 11,000 people lost their lives – exactly the same number as were killed by Ebola. What’s more, given the severely limited distribution of mosquito nets and preventative drugs, up to 3.5 million additional cases have gone untreated. **w**



PHOTOS: Alamy

V-22 OSPREY

For decades, the development of the V-22 Osprey looked like a suicide mission. Today, the Osprey is one of the US Army's most important multi-purpose weapons. Meet the vertical takeoff plane that defies the laws of physics

THE PLANE THAT DOESN'T NEED A RUNWAY



LIFT OFF!

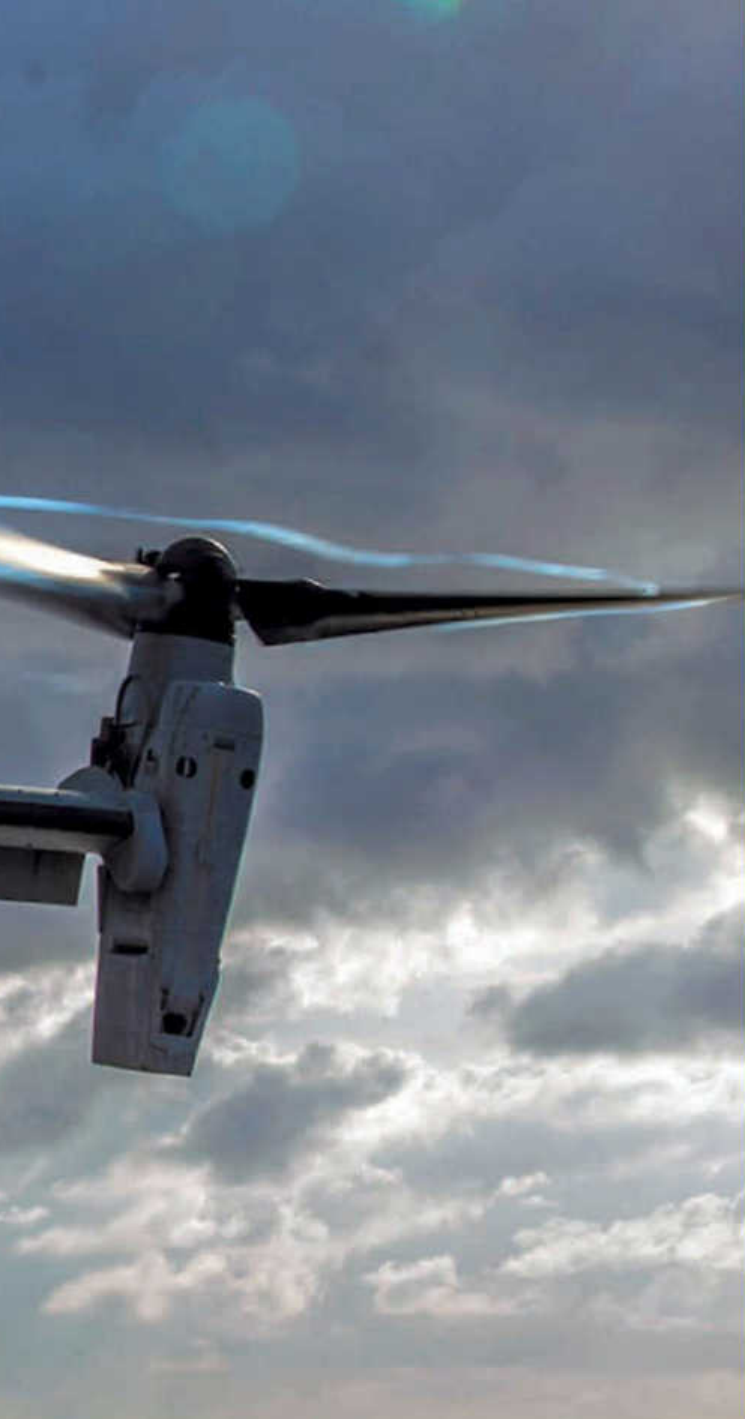
Use the free viewa app and scan this page to see the groundbreaking V-22 Osprey in action. And more!

SOMETHING FROM SCIENCE FICTION
What looks like a scene from a *Star Wars* film has now become reality: more than 200 V-22 Ospreys are being used around the world by the US Army.



PRECISION LANDING

In 2011, the first rescue missions were flown into the former war zone in Libya. The aircraft were launched from the USS Kearsarge in the Mediterranean.



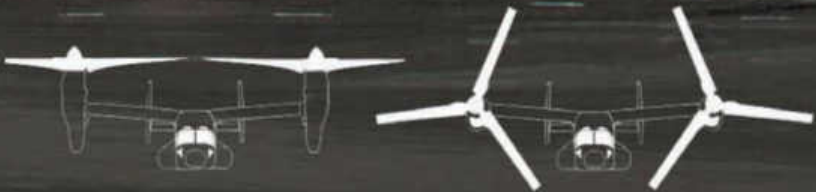
NON-STOP ACROSS THE ATLANTIC

The Osprey can fly non-stop for thousands of kilometres. It's pictured here refueling from an MC-130H Combat Talon II.



FOLDABLE HYBRID

To save space on the aircraft carrier, the wings of the MV-22A model can rotate 90 degrees and the rotor blades are foldable. This combined effect reduces the aircraft's footprint to just 19 x 5 metres.



HELICOPTER

PLANE

HELICOPTER TO PLANE IN 12 SECONDS FLAT

Thanks to its swivelling rotors, the V-22 Osprey can be converted into a transport plane in as little as 12 seconds. The 6,000 horsepower engines and 12-metre-diameter rotor blades can then accelerate the machine to 515km/h.



S

hortly before midnight the aircraft carrier USS Kearsarge receives an emergency call:

"F-15 pilot down!" A US fighter pilot has been shot down over the Libyan Desert – behind enemy lines. Although he managed to eject and has radioed in his coordinates, it's

only a matter of time before the enemy finds him. The commander of the American aircraft carrier in the Mediterranean is acutely aware that every second counts. But there are a distinct lack of runways in that part of the Libyan Desert and a helicopter would take at least 90 minutes to reach the downed pilot. There's only one machine that could save him now. "Scramble

the Osprey!" orders the commander. The V-22's inaugural rescue mission is about to begin...

OPERATION BEHIND ENEMY LINES

Just two minutes after the order to deploy is given, the V-22's three-bladed rotors begin to turn. The two rotors spin in opposite directions and produce lift, allowing the 17-ton

NO ROOM FOR LUXURY

Sgt Edilberto Malave of the 8th Special Operations Squadron conducts a pre-flight inspection of the interior. The Osprey can hold up to 24 soldiers plus their kit.

“Without the V-22, the rescue operation in Libya would have been impossible.”

PILOT ERIK KOLLE, Marine Tiltrotor Squadron



i

TWO HEARTS OF THE V-22

The V-22 Osprey is equipped with two Rolls-Royce AE 1107C Liberty engines. At full power each of them can generate 6,000 horsepower.

back towards the Mediterranean. Kolle is convinced of one thing for sure: “Without the V-22, the rescue operation in Libya would have been impossible. Sure, we could have used a Black Hawk or another helicopter. But it would have taken twice as long to reach the pilot. In all likelihood, the rebels would have already taken him hostage by then.”

The operation in Libya, the first military rescue using an Osprey, was the culmination of a lengthy 24-year development phase. During this period, the US has invested \$36 billion in the largest hybrid helicopter in the world. It was a project that many experts thought would be impossible. And, at first, it looked as if the critics would be proved right. There were numerous accidents, and at least 30 people lost their lives during the live test phase of the Osprey between 1991 and 2005. ➤

machine to take off vertically. Then, when he's about 100 metres above the aircraft carrier, pilot Erik Kolle tilts the two Rolls-Royce AE 1107C engines and their rotors 90 degrees forwards. In under 12 seconds, the aircraft has been transformed from a helicopter with six rotor blades to a plane with two giant propellers.

Kolle then pushes the thrust lever and the machine accelerates away.

The Osprey's top speed is 515km/h, around twice as fast as the military's legendary Black Hawk helicopter. This allows the search and rescue team to carry out their TRAP (Tactical Recovery of Aircraft Personnel) mission extremely quickly. So quickly, in fact, that just 30 minutes after the start of the operation, the Osprey has picked up the stranded pilot and is heading



Initially, it wasn't just the faulty hydraulics that gave engineers sleepless nights. The extreme weight of the tiltrotors was a serious cause for concern, too. The Osprey was particularly susceptible to 'vortex ring state', a condition in which vortices normally blown clear of the rotor blades become trapped around the rotor. This prevents the

production of thrust and results in a sudden descent. In addition to this, the aircraft also suffered from a short circuit flow to the rotor blade tips, which caused buoyancy to decrease rapidly and strong vibrations to occur – meaning the plane was difficult to control. Both these factors led to a number of fatal crashes during testing: the

hybrid aircraft would suddenly plummet like a stone, carrying its passengers to their deaths. It was a state of affairs that resulted in new guidelines on the rate of descent – a maximum 240 metres per minute at a minimum 74km/h of air speed.

The manufacturer Bell Boeing also added a warning light and audible warning system to the instrument



REINFORCEMENTS FROM THE AIR
The V-22's maximum takeoff weight is 30 tons. The hybrid aircraft can supply troops on the ground with weapons, food, tents and other equipment.

“It’s almost like an F-18 fighter jet and Black Hawk helicopter have spawned a baby. The Osprey gives us completely new options on the battlefield.”

V-22 PILOT LARRY NICHOLS

load capacity (it can carry twice as much as a Chinook helicopter). What’s more, it doesn’t need a runway to get airborne – and when its rotor blades are horizontal, it can put each wheel down on a piece of ground little bigger than a beer mat. It’s got everything you need to evacuate troops trapped behind enemy lines or to rescue wounded soldiers in remote regions. Little wonder, then, that the US Army is currently flying more than 200 of the machines.

“It’s almost like a F-18 fighter jet and Black Hawk helicopter have spawned a baby. The Osprey gives us completely new options on the battlefield,” says pilot Larry Nichols.

And if the enemy waits for the Osprey to land before launching an attack? Then they’ll have the aircraft’s Interim Defence Weapons System, or IDWS, to contend with. Mounted under the belly of the V-22 is a .50 calibre machine-gun, which is controlled by the co-pilot using a joystick. The gun fires 3,000 rounds a minute and can fully rotate 360 degrees. This heavy weaponry can clear landing zones in two minutes flat, leaving the Osprey clear to pick up its cargo – or drop it off. **W**

panel. “The machine is relatively easy to control in level flight, but there’s a tricky area whenever we initiate a vertical descent and pivot the rotors,” explains Erik Kolle.

HOW DO YOU LAND 17 TONS ON A BEERMAT?

Despite the aeronautical challenges faced by the V-22 Osprey’s pilots,

experts are now convinced that the tiltrotor will replace conventional transport and rescue helicopters like the Chinook and Black Hawk.

There are several reasons for this: the V-22’s extreme range (1,600 kilometres, three times that of a Black Hawk), its maximum altitude (8,000 metres, enough to avoid most missiles) and its gigantic

Australian
GEOGRAPHIC

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The
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L&P DIGITAL
PHOTOGRAPHIC

TRUE OR FALSE?

Dolphins are extremely clever.
Humans have five senses.
Wet hair will make you ill.
We put some of the most
commonly repeated bits of
'knowledge' under the microscope

33 EVERYDAY MYTHS

BUSTED!



TO SURVIVE A **FALLING LIFT** YOU SHOULD JUMP JUST BEFORE THE CRASH

It sounds pretty logical: the lift is hurtling towards the earth, so jumping a few metres before it hits the ground could save your life – even if the elevator is destroyed in the process.

But it's a myth: for one thing, choosing the right moment to

jump is difficult to judge.

Secondly, a person in the lift has the same fall rate as the lift itself and no human could offset that by jumping. Even a perfectly timed leap wouldn't help. If the elevator was falling at 160km/h, you would be too – even in the air – and that

would definitely be deadly. To survive the impact, you'd have to jump faster than the speed at which the lift was racing down, which would be impossible.

Thankfully, modern lifts are so well protected against collisions that you're extremely unlikely to ever encounter such a scenario.

HUMANS HAVE **FIVE SENSES**

Seeing, hearing, smelling, tasting and touching – that's how Aristotle defined the five human senses 2,400 years ago, a description that continues to limit common knowledge on the subject today. In fact we are far more 'sensitive' than we think: and not because of a 'sixth sense', a term usually used to mean a supernatural, intuitive ability. Our senses encompass a whole range of concrete skills: we can keep our balance even on tiny areas and can instantly find any of our own body parts with our hand – even in total darkness. We can estimate temperatures pretty accurately and perceive pain almost anywhere on our body, as well as inside it. Hunger and thirst are also vital sensory perceptions.

We can even develop new abilities: blind people can gain an impression of the room surrounding them by perceiving the echo of their own sound waves in a similar way that bats use echolocation. The body also possesses more measuring stations that we don't consciously perceive, like the blood pressure receptors in the throat.

Some scientists argue that humans have a Jacobson's organ that can perceive pheromones. These are scents that trigger specific chemical reactions in the body, including a preference for a particular romantic partner. Androstenone, which is found in our sweat, can make men more attractive to women.

HAIR AND NAILS KEEP GROWING AFTER DEATH

Death ends all cell processes. Nails and hair may appear as if they keep growing, but this is because flesh shrinks as it dries out and water evaporates from the body. As the skin retracts, the nails and hair appear longer as the body shrivels. Fingernails and beard stubble might look more prominent – but they're not actually growing at all.

DOLPHINS

ARE THE MOST INTELLIGENT ANIMALS

Their big brains and the complex structure of the cerebral cortex long led zoologists to believe that dolphins must be extremely intelligent. Members of the toothed-whale species can learn movement sequences very quickly. But their brain isn't useful for anything much harder than that and they are outshone by both pigeons and rats in problem-solving and memory exercises. Scientists suspect that because the dolphin's brain contains more supportive tissue and has relatively few nerve cells, they prefer to use their large brains for regulating body temperature instead of thinking.

RAINDROPS ARE TEAR-SHAPED

Despite the popular depiction of raindrops as tear-shaped, small raindrops are spherical and larger ones are shaped like a burger bun. Air resistance on the bottom of the raindrop

is greater than on its top. The surface tension at the top makes the raindrop more spherical while the bottom flattens out. When the radius exceeds 4mm it breaks up into smaller drops.

COCKROACHES

COULD SURVIVE A NUCLEAR APOCALYPSE

Yes, but they would become infertile and lose their ability to produce offspring. An organism's ability to withstand radiation depends on the speed of their metabolism: the more often cells in the body divide, the more sensitive the organism is to radiation because it's at the precise moment of replication that cells are at their most vulnerable. Mammals have a relatively fast metabolism, but in cockroaches the process is much slower. They are around six to 15 times more resistant to radiation than humans – and survived in Hiroshima just 300 metres from where the atomic bomb fell.



The Earth rotates on its axis every 24 hours – does this influence the direction that water flows in?

IN THE NORTHERN AND SOUTHERN HEMISPHERE

WATER ROTATES DOWN THE DRAIN IN DIFFERENT DIRECTIONS

Yes, but only in theory. Nature will always take the most direct route: wind blows from regions of high pressure to those with lower air pressure, and seawater low in salt balances itself out via the currents. But because the ground moves due to the Earth's rotation – and it moves faster the closer

you are to the equator – these currents are deflected: in the northern hemisphere to the right, in the southern hemisphere to the left. This is known as the Coriolis effect, but its influence is only experienced on very large areas. A bathtub is actually too small for these forces to really affect the water flowing down the drain.

WET HAIR WILL MAKE YOU CATCH A COLD

Rhinoviruses are generally responsible for colds – and they're pretty indifferent as to how warm or cold we're feeling. However, our body cools faster when our hair is wet, which reduces blood flow in the mucous membranes – the attack point for viruses. But, experiments have not identified a link between body temperature and getting the sniffles.

HOT WATER FREEZES QUICKER THAN COLD WATER

It sounds unbelievable, but a glass of hot water freezes more quickly than a cold one. There's still no widely accepted explanation for what's known as the Mpemba effect, especially because it doesn't happen under all conditions. One theory suggests it might be to do with hot water moving more and thus losing more warmth from the outer walls of the vessel. In addition, hot water evaporates faster which reduces the volume left to freeze. Last but not least, impurities in the water such as bacteria, dust and dissolved salts also lower the freezing point. As hot water contains fewer impurities, the freezing point is not reduced and it becomes ice more quickly.



MOBILE PHONES CAN SUDDENLY EXPLODE

In actual fact, a mobile phone does hide a certain risk because lithium-ion batteries are usually built into the device. A 20-micrometre separator is usually the only thing keeping the positive and negative electrodes apart. If these are contaminated by foreign particles during manufacturing, a dangerous chain reaction can be set in motion: a mini short circuit causes the entire energy to discharge in one go. If the temperature rises above 150 degrees Celsius, a fire or an explosion could result. That's why it's unwise to charge your mobile while you're asleep.

LEMMINGS COMMIT SUICIDE

Entire groups of lemmings plunging headlong over cliffs en masse – this myth goes back to a Disney documentary called *White Wilderness*. In reality, the production team lent a hand by staging the vole species' apparent death wish. It's true that the size of the population fluctuates from year to year, which leads to mass migrations. And in the process many animals meet their deaths – but by no means voluntarily. The animal filmmakers placed the lemmings on unstable ground and chose a canny camera angle. And as a result some lemmings really did fall over the cliff to their deaths.

X CORAL IS ONLY FOUND IN THE TROPICS

Roughly 6,000 different types of coral exist on Earth – and 20 of them are found in north European waters. But these cold-water corals are far less researched than their diver-friendly tropical counterparts, which extend just a few metres beneath the water's surface. For that reason it's not that surprising that the Darwin Mounds was only discovered in 1998. They

form part of a belt of coral reefs that stretch from Norway all the way to Portugal. In the North Sea, around 160 kilometres off the north-west coast of Scotland, the reefs lie at a water depth of about 1,000 metres. The connected structures can grow over 40 metres high and extend over dozens of kilometres. These corals require no light and can survive single-figure water temperatures.



A FALLING BULLET CAN KILL A PERSON

The weight and the shape of a falling object determine how dangerous it could be to a human. If you were to drop a penny weighing 3.5 grams from a height of two kilometres, it would accelerate to a maximum speed of 150km/h: air resistance would prevent it from travelling any faster and it would barely harm a human on the ground. Shooting a bullet high into the air would be an entirely different story: the 10-gram bullet would fly up to two kilometres into the air before turning around and beginning to fall again. During the descent it would reach about 500km/h and could shatter a person's bones. It happens more often than you'd think: in the Greater Los Angeles area alone, 38 people died as a result of falling bullets from gun salutes from 1985 to 1992.



THERE IS NO GRAVITY IN SPACE

The gravity of an object is infinite, but it weakens with distance. The impression of zero gravity on the International Space

Station happens because of the rotation of the Earth – if the ISS were to stop moving, it would crash quite quickly because of Earth's gravity.

A PLANE CAN FLY BECAUSE ITS WINGS ARE A PARTICULAR SHAPE

Wing panels are curved, because the inflowing air must flow faster at the top than at the bottom. As a result, an upward lift develops. So how can some aircraft fly upside down then? Well, because this uplift is far too small to raise an aircraft. It's the angle of attack that is critical: the more air rushing over the wings, the stronger the upward pressure. Anyone who has ever held the palm of their hand from a moving car knows what is meant here. It is the Newtonian principle of force and counterforce in which air flows downwards so the plane must go upwards. Even with flat wing surfaces, lifting off would be possible.



SINKING SHIPS SUCK SWIMMERS INTO THE DEPTHS

That depends entirely on the ship: the bigger and heavier it is and the faster it sinks, the more it churns up the water. That means that sinking ships displace the water coalescing behind them creating a deadly whirlpool for those caught in the water. As a rule, however, passenger ships have many openings like windows and hatches. That means water flows into the ship's interior, reducing the lateral displacement of water and consequently the suction effect. This is where another phenomenon comes into play: the ship churns water and air into a mixture that is markedly lighter than seawater and therefore offers less buoyancy. Even strong swimmers can fall into the depths here, similar to getting sucked into a whirlpool.



SEAGULLS CAN DRINK SEAWATER

Humans die of thirst when they drink too much saltwater because it causes freshwater to be released from the cells. The effect is quite different in seagulls and other marine birds: the seawater initially makes the birds' blood saltier. But they have salt glands right above their eyes, which filter out the salt ions through a physical process. During this procedure a liquid forms that is twice as salty as seawater. The seagulls finally discharge this secretion via openings in their bill.

SWIMMING

WITH A FULL STOMACH IS A BAD IDEA

Don't ever go in the water just after a meal – that's the advice a whole generation of mothers have handed down to their children. A big meal needs to be digested, which requires a greater blood supply to

the stomach and intestines. Swimming (or any other exercise) means muscles also require more blood. What happens is that neither gets enough to meet its needs and the tissues begin to cramp. Waiting for 30 minutes or so after eating will decrease the risk of this happening.



A CHILLI PEPPER'S

STRENGTH IS FOUND IN THE SEEDS

Bite into a chilli pepper and you might experience instant, unbearable pain – depending on how much capsaicin it contains. This alkaloid stimulates the pain receptors in the body's mucous membranes and triggers the experience of extreme spiciness. But most of this isn't in the seeds, as many people think, but in the white spongy mass around the core that is called the placenta. This produces the capsaicin, which probably exists to ward off predators. But birds don't react to the heat of the chilli at all and eating chilli peppers helps with their digestion.

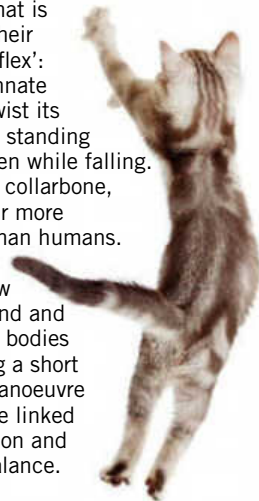


IN SUMMER THE EARTH IS CLOSER TO THE SUN THAN IN WINTER

It's the angle of entry of the sun's rays that determines the seasons, and nothing to do with the distance of the Earth from the sun. If the sun is low and small on the horizon, it is winter. The Earth is furthest away from the sun in July, bang in the middle of high summer in the northern hemisphere: the distance is 150 million kilometres. In January they find themselves five million kilometres closer to the sun.

CATS ALWAYS LAND ON THEIR FEET

Astonishing though it sounds, cats can survive falls from high buildings almost unharmed – almost always landing safely on all four paws. The animals are blessed with a unique skeletal structure and a flexible spine which together result in what is known as their 'righting reflex': a feline's innate ability to twist its body into a standing position even while falling. Cats lack a collarbone, but have far more vertebrae than humans. Their agile spines allow them to bend and rotate their bodies even during a short fall. The manoeuvre seems to be linked to their vision and sense of balance.



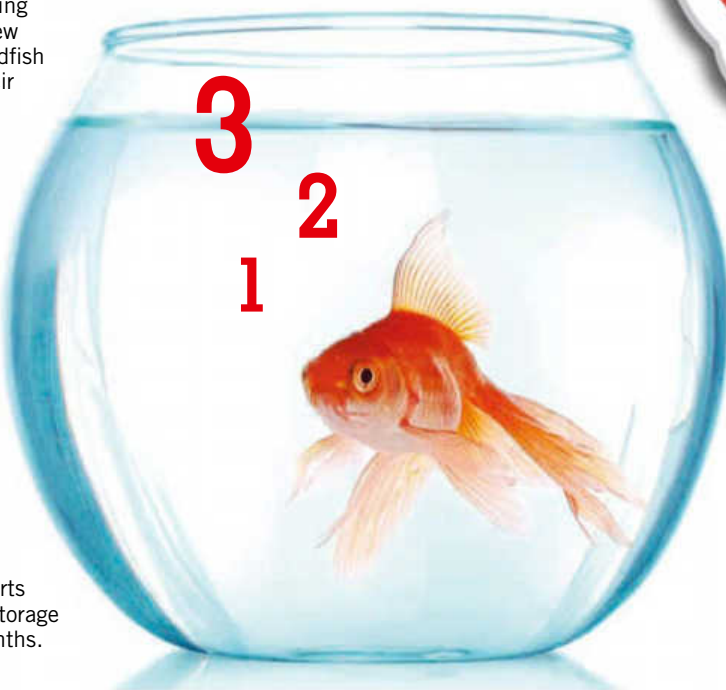
LIGHTNING NEVER STRIKES THE SAME PLACE TWICE

This myth lacks any scientific basis; after all, no thunderstorm on Earth can take notes on exactly where it has struck before. The Statue of Liberty is struck by around 600 lightning bolts a year. And humans don't get off lightly either: the American park ranger Roy Sullivan is famous for being struck by lightning seven times – and surviving.

A GOLDFISH'S

MEMORY LASTS 3 SECONDS FOR JUST

What an exciting life: every few seconds goldfish discover their unchanging environment all over again. Unfortunately that's pure myth: for this goldfish life is as drab as it would be for a human in a glass box. That's because goldfish don't have a 'fish brain', but rather an astonishing capacity for learning: a team of researchers succeeded in 'calling' them in to feed by using an audio signal. And in another study a school of fish learnt to press a lever to be rewarded with food – even though it was only active for one hour per day. Instead of a three-second memory, experts believe that goldfish have a storage capacity of at least three months.



HUMANS CAN ONLY USE

10% OF THEIR BRAINS

Muscles, bones and even nerve cells wither when they are not used. If the above myth about the brain, commonly attributed to Albert Einstein, were really true, our brain would be a barren wasteland. In reality, however, decades of research at both micro and macro level has not discovered any 'sleeping' regions in the brain – and certainly not 90%. All areas are active at some point and it's only the strength of use that fluctuates.

WATER BOILS MORE QUICKLY IF YOU ADD SALT

There are two opposing effects at play here: on the one hand a pinch of salt raises the boiling temperature of the water by between one and two degrees. That means it needs more energy and time to boil. On the other hand, salt also increases its capacity for warmth retention. That, conversely, means it gets warm with the same amount of energy more quickly. In practice both effects cancel each other out and a difference in time is barely noticeable. The 'trick' is useless for saving energy – but it can be used to cook meals to a hotter temperature more quickly.

A DOORWAY IS SAFE DURING AN EARTHQUAKE

Often the only parts of a building left standing after an earthquake are the entrance walls. But appearances can be deceiving, a doorway is not more stable than the rest of the house and an injury could be sustained from a swinging door. Crouching under a sturdy table is recommended.

EVERYONE SHOULD DRINK TWO LITRES OF WATER A DAY

This advice is completely outdated. It was first handed down by the US Dietary Association in 1945, but it relates not to the amount we should drink, but the amount of fluids we need overall. Food also contains liquids that can help to replace the 2-2.5 litres of water a human loses every day. A potato has a water content of 75%. Solid foods provide each one of us with about 900 millilitres of water per day. European recommendations say 1.5 litres of fluid in the form of drinks is enough per day. Too much water can actually be deadly: drinking six litres or more in one go could lead to circulatory collapse because the body would be swimming in salt.

GLASSES SHATTER AT HIGH PITCHES

Windowpanes, washing machines or bridges – all of these objects will vibrate if disturbed by an external stimulus. This is known as natural resonant frequency. Every piece of material has one, and for glass it lies between 200 and 2,000 vibrations per second. Sound waves are vibrations in air molecules. If they meet a glass at the right frequency and with enough pressure and volume, the vibrations will shake a glass until it breaks. Professional singers can shatter glasses with their voices using an amplifier.





FORMULA 1 CARS CAN DRIVE ON THE CEILING

A Formula 1 car can reach up to 370 kilometres per hour, far ahead of any normal car that – going that speed – would fly right off the ground. But the

700kg racers are so aerodynamic that they develop so-called surface pressure, which means they stick to the ground. At speeds of 240km/h, 2.7 times

their own weight is pressing down on the tarmac. Even at a lower speed of about 190km/h, an F1 car should be able to drive on the ceiling.

ONE SHOT IN THE TANK CAN MAKE THE WHOLE CAR EXPLODE

Everyone's seen it: in Hollywood a targeted shot at the escaping vehicle's fuel tank is enough to make the whole car go up in flames. But in reality even an entire machine gun salvo wouldn't do it – and special effects teams need dynamite to achieve such a feat. To ignite an explosion, a mixture of fuel and oxygen as well as a firing temperature is needed. This special combination is lacking in a fuel tank. An attack lasting no more than a minute could trigger a fire (but no explosion) – but even that's unlikely because the required temperature would not be reached. The principle is similar to a burning candle: the wax only burns around the wick because that's where the gas and air mixture can form. But the rest of the candle doesn't catch fire.

In 2007 Lamborghini recalled 400 of their Murcielago supercars due to a leaky fuel pump. Some of the cars caught fire, but they didn't explode. The only thing likely to explode on a car are the tyres that can overheat and burst. This can also damage the eardrums.



WATER CONDUCTS ELECTRICITY

Pure water conducts electricity only a billionth as well as a metal. It's dissolved particles, like salts, that make water a good conductor of electricity. For that reason tap water conducts electricity 1,000 times better than distilled water, and seawater is a million times better at conducting electricity.

VITAMIN C PREVENTS COLDS

Taking vitamin C as a preventative measure doesn't protect against colds – but it does lessen some of the symptoms if you already have the sniffles. Comparative studies carried out on physically fit sportsmen show that taking the vitamin daily has a small protective effect. Vitamin C does improve the effectiveness of the body's scavenger cells (phagocytes), which form part of our immune defences.

WHEN COWS

SIT DOWN, IT'S ABOUT TO RAIN

How can you accurately predict if it's going to rain? By visiting a farm. If all the cows are lying down, a rainstorm is on its way – or so the old wives' tale goes. Experts say this is nonsense. According to them, cows sitting down in a field means they're just chewing their cud, rather than preparing for a storm. **W**

THE WORLD WONDER OF ENIGMAS

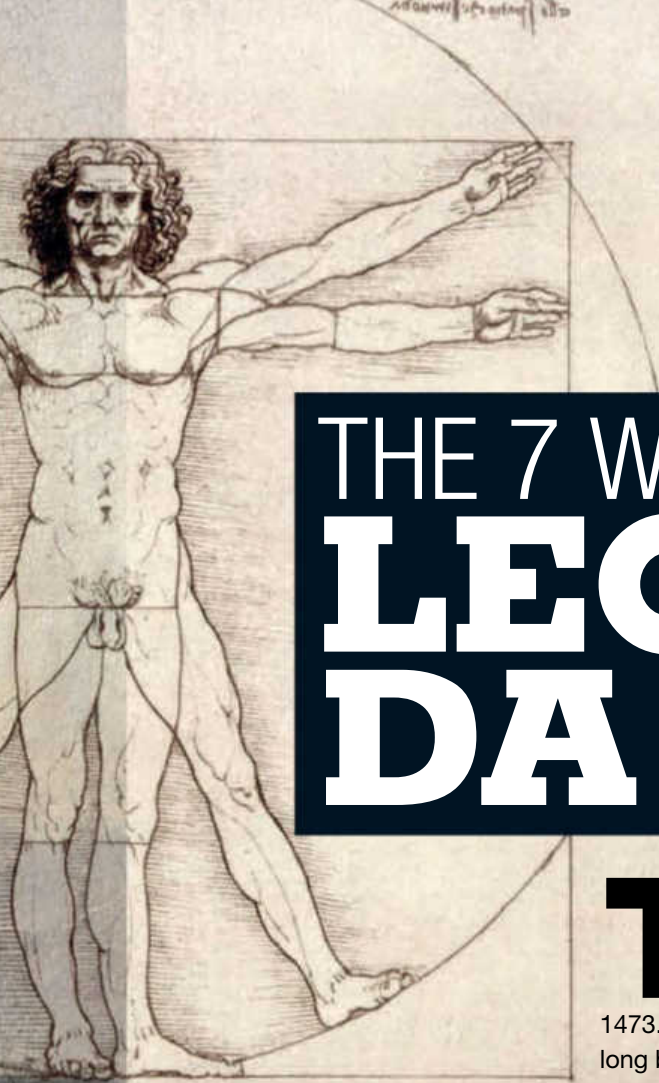
It is the most famous painting in the world. To this day debate rages over whether the *Mona Lisa* is smiling or not. Da Vinci used a technique known as *sfumato* to create a highly illusionistic rendering of her facial features, thus leaving the interpretation down to the viewer. The *Mona Lisa* also seems to be looking at the viewer – no matter which angle you observe it from. So even 500 years later she greets every single viewer with a different gaze.

THE WORLD WONDER OF HARMONY

For Leonardo the human is the crown of creation – he hopes to use the body to solve an eternal puzzle: the squaring of the circle. Leonardo believes that the proportions of the human body show how both a circle and a square can be drawn on the same area using just a compass and a ruler. He nearly succeeded with the *Vitruvian Man* [right] – Leonardo's symbol of harmony.

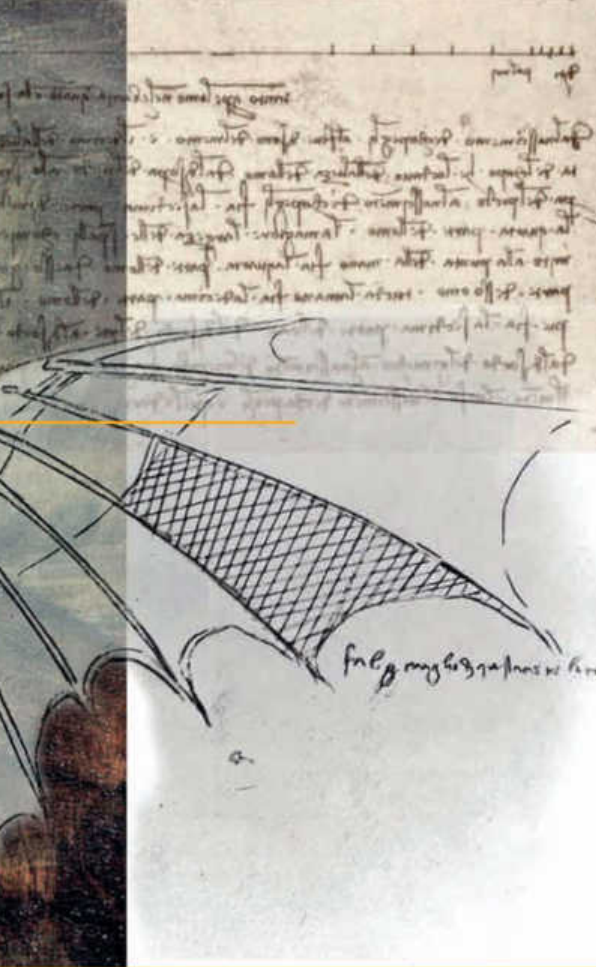
THE WORLD WONDER OF FLYING

If there had been engines in the 15th and 16th centuries, Leonardo might be considered the inventor of the aeroplane. Hundreds of years before the first manned flight, Leonardo sketched the basics of flying: stable, moveable wings, which would allow humans to travel smoothly through the air. It took 400 years for the Wright brothers to be able to surpass his inventions.



Almost 500 years ago, towards the end of the Middle Ages, Leonardo da Vinci died. Even today, his inventions still have the power to astound. Leonardo was far ahead of his time, like someone woken too early, while everybody else was asleep

THE 7 WORLD WONDERS OF LEONARDO DA VINCI



The place: a bustling market in the small Tuscan city of Verrocchio. The year: 1473. A painter's apprentice with long blond locks and a short coat mingles among the throng of people. He gazes at the small narrow cages crammed with cats, dogs and birds. "How much are they?" he asks the stallholder.

He is quoted an eye-watering price, but the young man pays without batting an eyelid. Despite being short of cash, he's only interested in opening the cage doors. Birds fly out; cats and dogs disappear into the crowd. The young man watches them and laughs. "Who is this fool?" ask the townsfolk, shaking their heads.

Just a few years later everybody knows the answer. He is Leonardo da Vinci. For many today, he is still the greatest genius to have ever lived. But 500 years ago, he was seen by the people of the Middle Ages as a dreamer, a fantasist and outsider – and many avoided him. Very few recognised his talent in art and in the sciences, but then very few ever truly understood Leonardo.

If you want to get to the bottom of Leonardo's story, you need to go back to where he grew up. Leonardo's home town is the village of Vinci in the hills of Tuscany in Italy. Beyond the village, the Apennine mountains rise up into the sky. Before it lies the fertile valley of the river Arno. Little Leonardo's jaw drops when his father tells him the story of Captain Cecco Santi for the first time. Cecco Santi betrayed his home town because of the love he had for a woman. The punishment for medieval nobility was to be thrown from the tower of Vinci's city fortress. But rather than hurtling towards the ground, Santi glides like a feather down to the Arno valley, where his beloved is waiting for him. Santi is free because love lent him wings. The truth in Tuscany is not far from this fairytale.

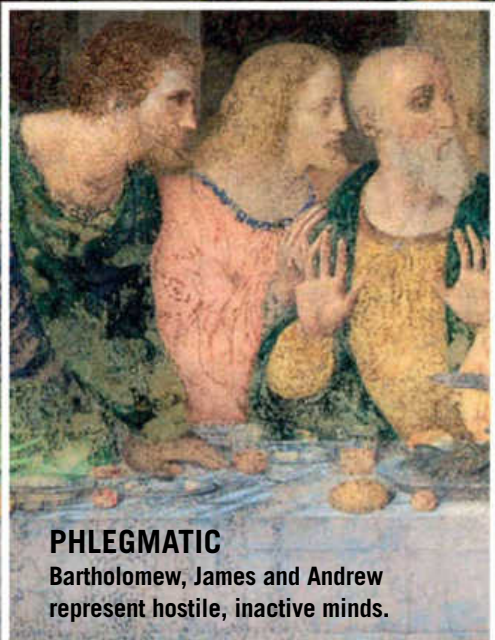
Being able to fly like Cecco Santi was a desire that made Leonardo da Vinci into the greatest universal genius of all time – and simultaneously the unluckiest and unhappiest. That's because, although in theory Leonardo fulfilled his dream by sketching the first flying machine in history, he lacked



5 THE WORLD WONDER OF THINKING

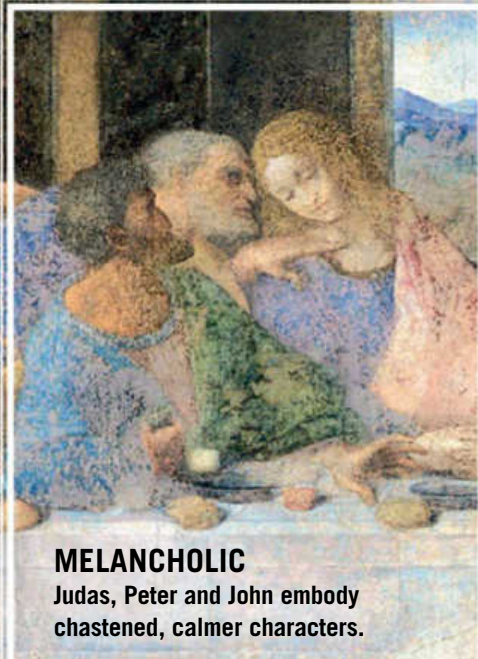
Leonardo worked on *The Last Supper* [below] for more than two years. The fresco united religion and science in a single picture. Leonardo's exceptional use of perspective guides the viewer's eye towards the dead centre of the painting: Jesus' right temple, which stands for the seat of rationality (Logos). And each group of three Apostles symbolises a character type from antiquity and thereby pagan temperaments...

5



PHLEGMATIC

Bartholomew, James and Andrew represent hostile, inactive minds.



MELANCHOLIC

Judas, Peter and John embody chastened, calmer characters.



LOGOS



4

THE WORLD WONDER OF ANATOMY

Leonardo da Vinci carried out dozens of autopsies. Highly illegal, just one of these experiments could have landed him in front of the Inquisition. But it was only through them that he gained knowledge of the human body, an insight that no other doctor at the time had. Leonardo had an understanding that modern science only achieved many centuries later.

the technology, modern materials and tools to make his dream a reality. He is like a time traveller who has mistakenly travelled into the wrong century. Leonardo's flashes of genius foreshadowed inventions that would only be achieved many centuries later.

As an architect he designed city building concepts that are only just coming into practice today. He constructed hydraulic engines, ball bearings, automated weapons, functioning cars with spring drives, armour, musical instruments and houses with central heating. He was the first person to draw a foetus in its mother's womb, so anatomically accurate it could be a CT scan. And at the end of his life he'd even worked out human anatomy by conducting dozens of autopsies – at a time

when conducting just one autopsy was enough to be burned at the stake as an associate of the devil.

VICTIM OF HIS OWN GENIUS

Even during his lifetime an air of mystery surrounded Leonardo. He could write with both hands, backwards. Sometimes the pages he creates are filled with numbers, but in the middle there are sentences like 'The sun does not move'. Five hundred years ago the belief was that it was the Earth – and not the sun – that stood still and that all the planets moved around it. He creates masterpieces, although his active, curious mind means that he hurries from one work to another. He finds himself easily bored even by things that he was enthusiastic about just moments before.

THE FOUR CARDINAL VIRTUES

The most important representative of the four virtues was the ancient philosopher Plato. Leonardo also placed man's reason and rationality in the centre – instead of divine inspiration.

JUSTICE

WISDOM

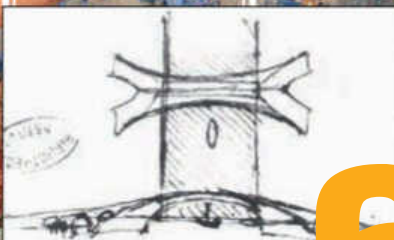
COURAGE

MODERATION



SANGUINE

Thomas, James the Greater and Philip react in an indignant but empathetic way.



THE WORLD WONDER OF ARCHITECTURE

In 1502-03 Leonardo created this sketch for a bridge that would lead from Europe to Asia over the Bosphorus. Nobody believed that this construction idea would work. But it was built in Norway, to his original design, and opened in 2001.

6



CHOLERIC

Matthew, Jude and Simon gesticulate excitedly.

Today very few paintings are considered genuine 'da Vincis'.

"One day I will know everything and will have mastered all of the arts that reveal the biggest secrets of mankind," says Leonardo. To this day many people think he saw belief in God as a superstition – one that he ridiculed. That's probably why one popular theory suggests that it was Leonardo da Vinci who created the legendary Shroud of Turin, using a primitive camera and light-sensitive chemicals. The same shroud that many believe held the body of Christ after his crucifixion.

Was Leonardo really not a religious man? The truth is revealed in his greatest masterpiece *The Last Supper*. For Leonardo the work was far more than an artistic challenge. It is clear that this painting was a manifesto of his

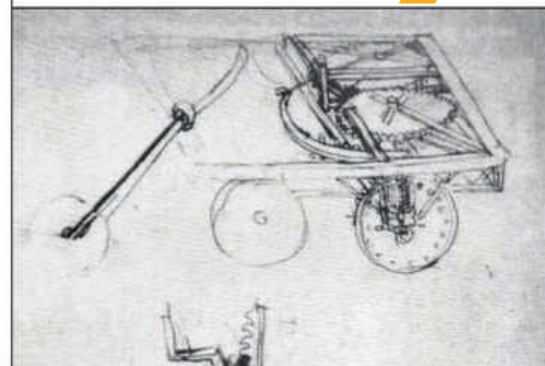
greatest convictions. The fresco is full of symbols and allusions. It is about the reconciliation of religion and science. Leonardo assigns the 12 apostles the four basic temperaments of man [see image above] and he glorifies the cardinal virtues of the philosophers of antiquity (justice, wisdom, courage and moderation) as the principles of a worthy and just life on Earth. His message? Rationality and faith are a unit, not a contradiction.

Once again, it seems that Leonardo was ahead of his time: at the end of 2014 Pope Francis formally announced that scientific knowledge is not at odds with Catholic beliefs. **W**

THE WORLD WONDER OF MOBILITY

The sketch below held its secrets for more than 500 years. Only in 2009 did researchers succeed in decoding Leonardo's invention. What emerged was the first 'automobile' in the world. It was powered by coiled springs and also featured programmable steering and brakes.

7



THE WIND MONSTER

You're looking at one of the largest wind turbines in the world, its huge blades generating massive amounts of energy. Meet the beast that was considered impossible to build

**PRECISION WORK AT
120 METRES UP**

Installing the new wind turbine on the Østerild test field in Denmark is a technical challenge. Two gigantic specialised cranes are needed to lift the 25-ton rotor blades onto the 120-metre-high engine room. They do this with pinpoint accuracy.

80 METRES PER SECOND

The three rotor blades rotate at a speed of up to 80 metres per second. Every year, they produce around 25 million kilowatt hours of electricity – enough to supply 6,000 households with power.

18,600-SQUARE-METRE WINDBREAKER

The rotor covers 18,600 square metres, the same area as two-and-a-half football pitches. It has a total diameter of 154 metres.

12-MONTH STRESS TEST

The development of the B75 rotor blades took several years. The prototype SWT-6.0-154 wind turbine was then installed at the Østerild facility in Denmark and tested in real conditions for 12 months. The first production models have already been installed in Europe.

20% LIGHTER

The B75 rotor blade is the world's largest fibreglass component cast in one piece. Thanks to quantum blade technology, it's 20% lighter than it would have been had it been made using traditional methods.

75 METRES

WIND RESISTANCE OF UP TO 90KM/H

The new B75 blades are so robust and aerodynamic that the motor only automatically disconnects when the wind speed reaches 90km/h.

The 680-horsepower lorry crawls across Denmark's lowland plains at a snail's pace. Its cargo? The largest building component ever to be transported on land. At 75 metres long, carrying the B75 rotor blade would be a challenge for even the most experienced truck driver. After eight long hours, it finally arrives at the test site at Østerild in the north of the country. Waiting there are two other identical rotor blades and the 200-ton nacelle (engine housing) of the SWT-6.0-154 – a wind turbine with dimensions considered physically impossible just a few years ago.

There's a perennial problem when building a wind turbine: the larger it is, the more energy its rotor blades can generate. But, at the same time, the costs and risks rise with every additional kilo in weight and metre in height. "The bigger the rotor, the more stress the construction must withstand.

The foundations and turbine tower must be incredibly stable, which costs extra millions," explains

Henrik Stiesdal, the technology officer behind the SWT-6.0-

154. To this end, Stiesdal and his engineers

developed ultra-light fibreglass

components

for the rotor

blades of

the mega

windmill [see

left]. Thanks

to this



THREE GIANTS

Each one of the new SWT-6.0-154 wind turbine's three rotor blades is 75 metres in length – measuring almost the same as an Airbus A380's wingspan.

construction method, experts are now convinced that 100-metre-long wind blades will soon be possible.

At the test site in Østerild, 12 special cranes hoist the 15-metre-long nacelle onto the top of the tower. Here, 120 metres above the ground, the wind energy from the motors is collected and transferred. After hours of precision work, the three rotor blades are then attached to the nacelle with the help of the huge cranes. A few days later and the biggest wind turbine is operational for the very first time.

Performance data is compelling: at wind speeds of 35km/h, the rotor blades capture energy from 200 tons of air every second. That means a single wind turbine can produce enough electricity per year to supply 6,000 households with energy – a statistic that wind power engineers could have barely dreamed about, even ten years ago. **W**

WORLD EVENTS



IMPOSSIBLE TO ESCAPE!

Use the free viewa app and scan this page to discover the world's most secure prisons. And more!

THE PRISON TESTER

How secure is a prison? What are its weak spots? And how difficult is it to escape from? Parkour Generations is the only company in the world trying to answer these questions



ESCAPE RISK

To jump from roof to roof you require discipline, body control and excellent self-perception. But this free-runner isn't just trying to improve his parkour skills. He's practising for a prison break...

T

Thick concrete walls obstruct his view of the outside world. A quick glance to the left and the right – and then suddenly he's off, running straight at the wall in front of him. The man leaps up and clings onto a near-invisible ledge about three metres off the ground. His right hand gropes along the stones, before finding some grip in a small hole. Then he draws himself up and, just a few moments later, he stands triumphant on top of the prison wall.

"Twenty-eight seconds, Dan," one of his partners calls up. A shade under half a minute to scale some six-metre-high stone walls – in a high-security wing. What might at first look like a spectacular prison break is in fact a safety test.

This is how Dan Edwardes earns a living. Edwardes is the founder of UK-based Parkour Generations. The 39-year-old and his team are the only company in the world to test prisons, psychiatric wards and the houses of the super-rich – to determine how easy it is to break in – or break out. And they almost always find a way to do it. The company's 11-strong tactical team carry out about ten of these 'penetration tests' a year, mainly in the UK and the US.

"YOU CAN BREAK INTO ANY BUILDING – IT IS JUST A QUESTION OF TIME AND CREATIVITY."

Most members of the tactical team are not only talented traceurs – a name for a practising parkour artist* – they have also worked in various branches of security for long periods of time. "You have to be physically fit. You can make good use of that with parkour. Thanks to our experience in security we are particularly aware of weak spots in high-security buildings," explains Dan Edwardes. And sometimes these security gaps are enormous...

Only one in ten of the sites tested by Parkour Generations are so safe that no improvement measures are needed. The team can gain access to almost any building – and they use the same route to get out again. All that's required? Time, fitness and determination. "People who are locked up can be very creative when it comes to finding an escape route," says Edwardes. Naturally, he won't reveal detailed information about the weak points of any buildings that he's tested – that's part of the deal with his clients. Security gaps also vary from building to building. Common weaknesses, however, include:

1. Walls that are too low and ledges that are easy to reach.
2. A restricted field of illuminated vision from the watchtowers.
3. A lack of staff.
4. The unfavourable construction of high-security buildings.

One example that highlights these deficiencies are walls that are built at relatively narrow angles in relation to one another, making them easy to climb. With a bit of muscle, it's possible to virtually anchor yourself between the two and run up the walls. But if you think that only specially trained experts could find a way out of a high-security building, you'd be wrong.

ENDLESS OPPORTUNITY

Roofs, ledges and air conditioning systems offer many potential opportunities to escape.



KEEPING GUARD

The watchtowers are manned around the clock. Floodlights illuminate the surroundings. But there's always a blind spot where you can hide and then escape from.



HIGH JUMP

With enough momentum and precision, a person can easily jump from roof to roof.

"WHEN HUMANS ARE DETERMINED ENOUGH, THEY CAN DO UNBELIEVABLE THINGS – EVEN WITHOUT ANY SPECIAL TRAINING."

High-security prisons are becoming increasingly difficult to escape from. It's even tougher for US prisoners who are locked up for 22 to 24 hours a day in high-tech facilities. Plenty of time to dream up an

*Parkour is a type of free-running that typically takes place in an urban environment. Traceurs use running, jumping and climbing techniques to negotiate obstacles.

HOW EASY IS IT TO ESCAPE FROM PRISON?

MAXIMUM SECURITY

The bars on the cell windows are made of strengthened steel. The doors are doubly reinforced and can only be opened electronically. Despite this prisoners still manage to escape.

NO WAY OUT

The entrance and exits have multiple safeguards: electric gates and fences, motion sensors, even a police car is always at the ready. It would be tricky to escape via this route. But elsewhere...

LONG WAY DOWN

The walls are up to 15 metres high. They can only be descended by using cables or via drainpipes attached to the wall.

3m wide

15m high

THERE ARE
ENDLESS
OPPORTUNITIES
TO ESCAPE FROM
A PRISON

escape plan, some would say, and perhaps why US prisoners have a greater success rate in escaping from jail. In 2006 Quawntay Adams succeeded in escaping from the state-of-the-art Alton City Jail in Illinois, to date still the only inmate to do so. In spite of the CCTV in his cell, he cut through the steel roof with a smuggled saw blade and managed to get outside via the air conditioning system. In 2014

convict Michael David Elliot, serving four life sentences for murder, escaped from a high-security facility in Michigan after tearing a hole between two electric fences with his bare hands. He didn't receive a shock because the electricity was switched off and the motion sensors had also failed. Inmates of maximum-security prisons sharpen their observational abilities over time. They discover

escape routes that wouldn't occur to your average person.

"IF WE CAN'T FIND A WAY IN OR OUT, IT'S UNLIKELY THAT A PRISONER WOULD SUCCEED IN DOING SO."

"Our job is to find these routes and then show the authorities how to make their buildings safer," says Edwardes. Many prison authorities

A PARKOUR RUNNER HARDLY HAS ANY TIME TO THINK



ARM SUPPORT

When edging up a wall, the arms have a supporting function. The triceps are under the most strain.



SENSIBLE SHOES

Narrow soles are important so that you can dig into the stone. The knees should be bent to provide a more secure footing.



are realising that their safety measures have only ever been tested in theory. Most of his clients think that there's no way out of their buildings and are shocked when Edwardes and his team manage to do just that. "It's because they don't perceive the architecture as we do," says Edwardes. Traceurs use their natural environment and tackle obstacles head-on instead of going around them. "We use roofs,

windows, air conditioning systems and drainpipes to get in or out of places. The opportunities are endless." Parkour Generations also offers training courses on breaking in and breaking out. Participants are trained in balance, jumping techniques and coordination. They also develop a nose for the best way in and out of a building. During this process the jail-testers need to consider how food gets into the

building. Which routes do they use? Are they safe? After all, any delivery van that comes in has to get out again. The team also analyses how food is delivered inside the building itself. These athletic and tactical skills are combined in the penetration tests – alone they are of little use.

So how do you manage to see a wall as a hurdle to scale rather than an obstacle? "With the correct

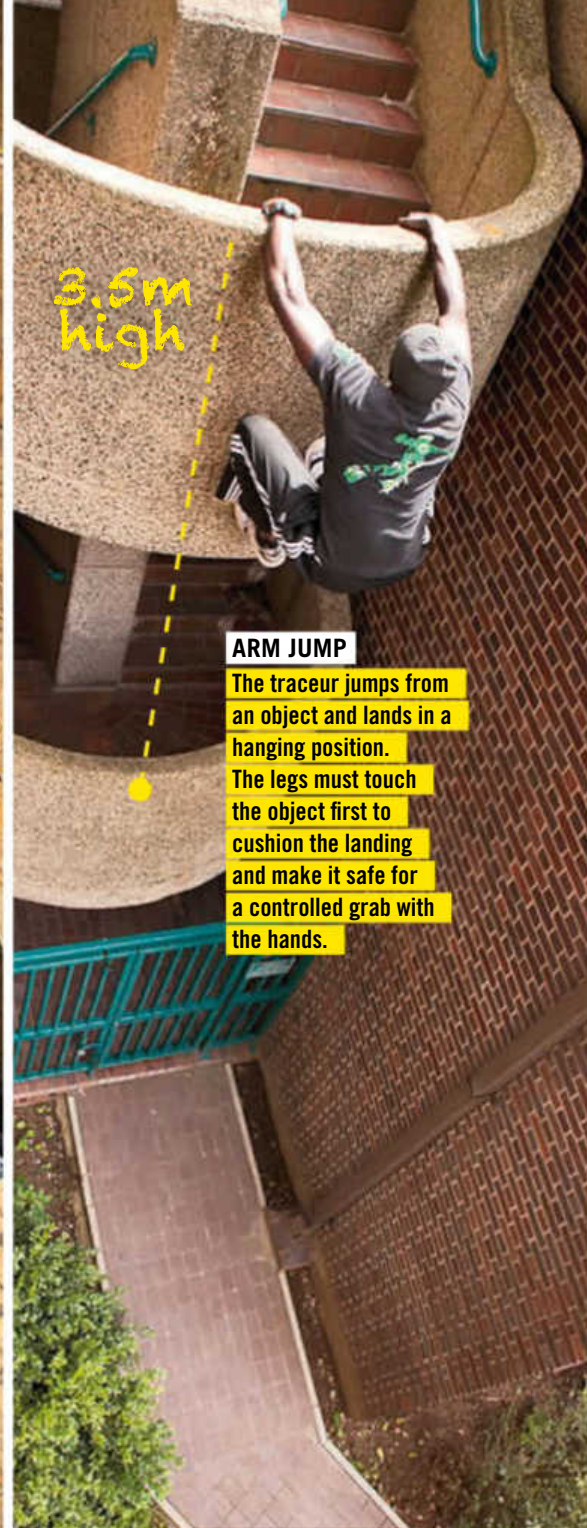


FINGERS CROSSED

To scale a wall, you need sufficient strength in your fingertips. The fingers must support the majority of the body weight.

LEG WORK

The traceur uses his legs to create a leverage effect, allowing them to scale the wall.



ARM JUMP

The traceur jumps from an object and lands in a hanging position. The legs must touch the object first to cushion the landing and make it safe for a controlled grab with the hands.

techniques and the appropriate momentum, it's not that difficult to catapult yourself upwards. Objects that were intended to be obstacles can actually become springboards that help you reach your goal. Through coordinated movements, new perspectives can be created," Edwardes explains.

The tactical team has already been practising these movement sequences for years to keep the

risk of injury to a minimum. Before a test, the team analyses the surfaces and materials used in a building's construction, takes into account the weather forecast, and measures the height of the walls and towers. Obviously, any potential escapees wouldn't have the luxury of checking these things in advance, so if Edwardes can't find a way in or out, it's highly unlikely that an inmate would be

able to escape. The physical prowess of the jail-testing team is also far beyond that of your average prisoner.

As for Parkour Generation's record escape time? An unbelievable 15 seconds. That's how long it took to get from the inner courtyard of a psychiatric facility to the car park. Edwardes smiles. "That one really opened the authorities' eyes, I can tell you," he says. **W**

THE MIRACLE OF DESE

How does the
desert act like
a time machine?

“**M**an fears time, but time fears the pyramids,” goes an ancient Egyptian proverb.

There are hardly any other monuments on Earth older than these vast tombs, built more than 4,500 years ago in the desert sand. Earth's deserts themselves are up to 80 million years old, but they're not just the oldest landscapes on the planet.

Whenever we enter a desert, we're also going back in time. The hot, dry landscapes preserve millennia-old artefacts like a time machine. Things that would only last weeks in other regions of the world can last almost forever in deserts. Chemical processes like putrefaction, decomposition and decay are slowed down dramatically. The Great Sphinx of Giza, one of Egypt's most famous monuments, would have become an unrecognisable lump of sandstone had it not been buried under the wandering desert sand. Only a few years after its completion, annual sandstorms buried the Sphinx's 70-metre by 20-metre body up to its chin. Just like the tip of an iceberg in the water, the mysterious sculpture hid beneath the sand and, in so doing, managed to survive undisturbed for more than four millennia.

GREAT SPHINX OF GIZA, EGYPT



RT SAND

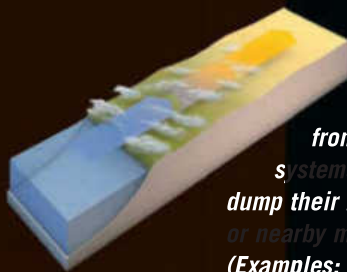
Each individual grain of desert sand contains more information about the planet than could ever be stored in libraries or on hard disks. And these tiny particles can even defy the laws of evolution as they transform the Earth's landscape in breathtaking ways

RIDDLE OF THE SPHINX

This photo of the Sphinx, taken in about 1880, shows a large part of its body hidden beneath the sand. The monument was almost completely buried by sand over the millennia because its plinth is located below the ground level of the desert. This protected the sculpture from erosion.

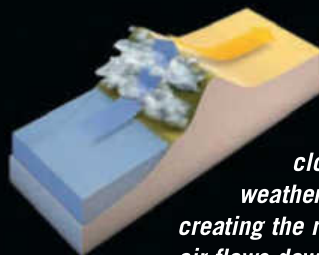


HOW DESERTS FORM



CONTINENTAL DESERTS

These are cut off from large weather systems. Arriving air masses dump their moisture on the sea or nearby mountains instead. (Examples: large parts of the Sahara, deserts of central Asia).



RELIEF DESERTS

Mountain ranges seal off these deserts from rain clouds. Precipitation falls on the weather-facing side of the mountains, creating the rain shadow effect, while hot air flows down the other side. (Great Basin Desert, USA; Taklamakan, China).

Can sand stop the progress of evolution?

Earth's biological clock began ticking nearly 600 million years ago when long-chain protein molecules developed into higher forms of life: evolution. Since then, nature has developed across the world, from small to large, from swimming to running. Only here, where the Atacama Desert in northern Chile meets the Pacific Ocean, has the clock stopped ticking. Two utterly different worlds are separated along the shore, as if by an invisible wall. The Pacific is the largest ocean on Earth and home to an unimaginable number of plants, protozoa and evolved animals, organised in wide-ranging food chains – a true cacophony of life. In comparison, the Atacama Desert is one of the most hostile places in the world. Scientists have discovered that the stark difference between the desert and sea is down to the unusual physics and location of the desert: no place on Earth is drier and, at 7,000 metres above sea level, no desert is higher. This geological height is caused by one thing: sand. It almost never rains in the desert, meaning that sediment is never washed into the sea. Just off the South American coast, the oceanic Nazca tectonic plate is subducted underneath the South American plate. Sediment normally acts as a lubricant between moving plates but, because it's missing here, the unprotected plates crash against each other, raising the Atacama Desert and neighbouring Andes Mountains.



TROPICAL DESERTS

These lie in the tropical zone. Rising air sinks towards the poles at the equator and loses moisture, causing precipitation to fall. Dry trade winds flow over the ground. (Baja California).



COASTAL DESERTS

These lie on the west coast of Africa (Namib) and the Americas (Atacama). Warm winds from the land spread above cold air currents from the sea. This means no water can rise and condense into rain clouds. Fog is formed instead.





ANCIENT RIVERS

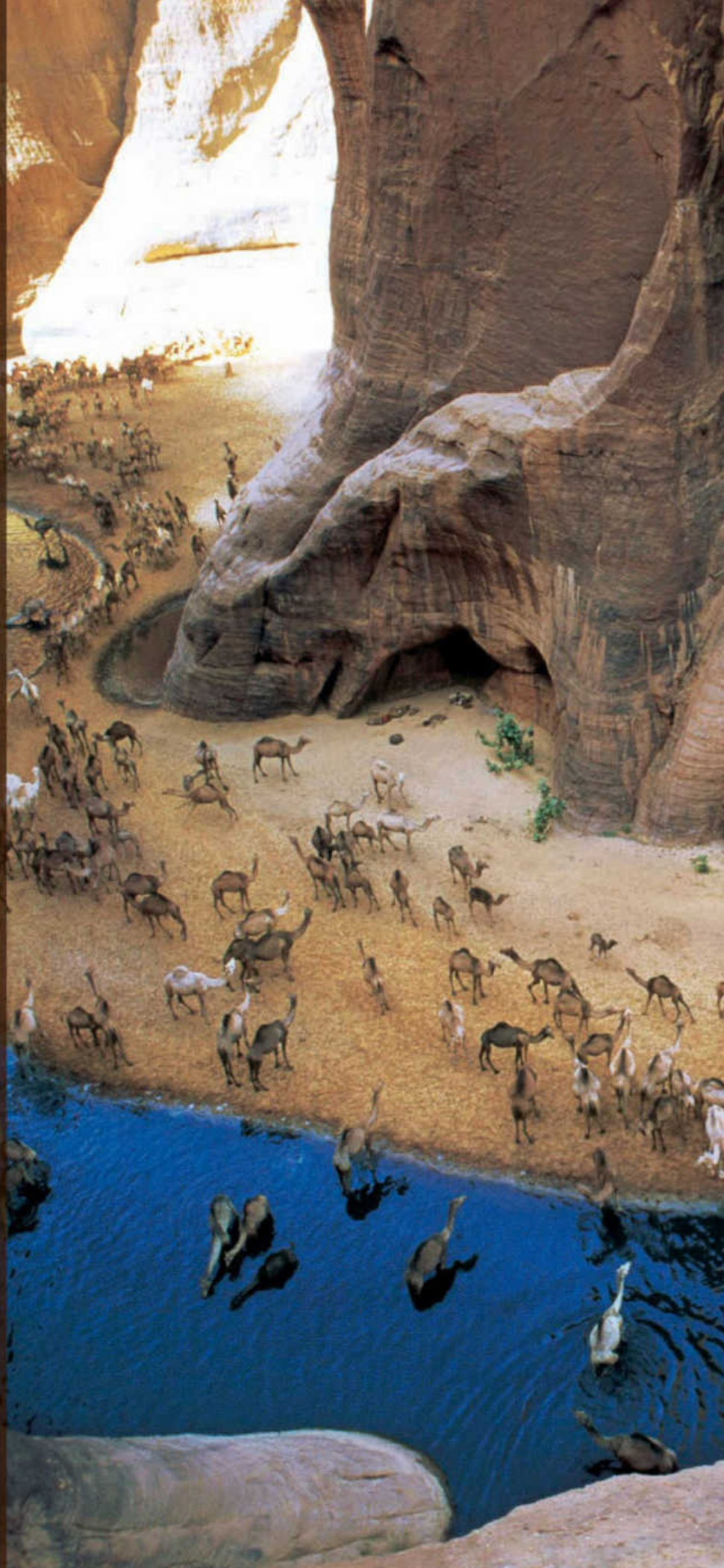
This satellite image shows ancient river systems in southern Africa.

What geologists find particularly interesting are the light blue structures of former streams, visible under the yellow dune formations. They may still contain water, hundreds of metres below the surface.

Are some deserts hiding secret water reserves?

Wild camels congregate in the Guelta d'Archei in northern Chad – a unique island of life. Living in complete isolation, the humped animals are a relic of a bygone era. The Sahara was once a gigantic wetland – geoscientists believe the Amazon flowed there 130 million years ago, until the huge Gondwana continent split apart into the smaller continents we inhabit today. The Amazon flowed into South America and Africa was left with around eight million square kilometres of desert: the Sahara.

The camels and a few species of fish aren't the only relics. A few years ago, researchers discovered desert crocodiles hidden in ancient watercourses metres below the surface. The desert itself provides the necessities for this hidden paradise: gueltas, natural bodies of water, are constantly filled by groundwater. And there's a surprising amount of moisture in the Sahara – thanks to the physical properties of desert sand. There are gaps between grains of sand, which account for approximately 30% of its total volume. This means that a ton of sand can absorb more than 300 litres of water. Only sand could have caused the formation of one of the largest freshwater reserves on Earth: a body of water lying under the Sahara that's as large as the Baltic Sea.



How can a grain of sand make a mountain disappear?

Sand has been gnawing at the rocks of Monument Valley in Utah for 50 million years, meaning the plateau has been eroded to just 1,900 metres from its original height of 2,100 metres. Bizarrely shaped mesas have formed where deposits of hard rock have weathered the erosion. But, in a few million years, it will all be flat.

No mountain range or imposing rock formation can survive when sand unleashes its destructive power. Erosion and weathering are part of a vast global cycle which sees every high point ground down. Sand rides on winds that always blow in the same direction. This means that grains of quartz (quartz is just three grades below diamond on the Mohs scale of mineral hardness) are thrown against rocks like a sandblaster.

And sand also uses a clever trick to shape the landscape – electricity. US physicists discovered that when particles carried by wind hit the ground, they form an electric field that draws other sand particles from the surface.

Wind isn't nature's only method for transporting sand – seas and rivers carry vast quantities of sediments and form landscapes like the Grand Canyon and Arizona's Antelope Canyon. But the impact of sand accelerated by wind is 2,000 times greater. And unlike water, wind can travel uphill.



NO CHANCE FOR BACTERIA

Bacteria like *staphylococcus aureus* [left] and fungi need moisture to survive. Only then can they decompose organic material. Sand absorbs moisture and thus helps to preserve old documents [right: manuscript restorer in a Timbuktu library].

How can sand stop time?

It's called the 'Atlantis of the Sands'. For centuries, the ancient trading city of Ubar in modern-day Oman was considered lost to the sands of the Rub' al-Khali desert. Then satellite photos appeared in the 1980s that showed a 100-metre-wide road, over which thousands of camels and mules once pulled heavy carts. The incredible thing is that the road was left untouched beneath the layers of sand, many metres deep. But desert sand isn't just capable of hiding architecture. Countless priceless writings from the former stronghold of Timbuktu would have been irretrievably lost had the sand not preserved the papyrus scrolls. Sand can absorb liquid like no other substance on Earth. Droplets of liquid stick particularly well to porous grains of sand because of their surface tension. The grains then join together to create a large surface area that absorbs a great deal of moisture. Before blotting paper was invented, sand was used to soak up excess ink from letters and documents. The arena of the Circus Maximus in Rome was covered in sand so that gladiators' blood could be speedily cleared away. Sand also soaks up the moisture needed for harmful microbes and fungi to survive. For this reason ancient scripts that were once written on gazelle skin, and the portraits of the dead on Egyptian sarcophagi, are perfectly preserved, untouched by small organisms that would normally cause them to deteriorate and decay over time.



“**B**

on appetit,” says Chris McKay as he watches the liquid slowly seep into the soil sample. All alone in the scorching 50-degree heat, the NASA

astrobiologist is doing something that has probably never occurred to anyone else before: he's 'feeding' soup to the Atacama Desert. But he's not trying to change the northern Chilean region's reputation as the driest place on Earth. Instead, McKay is trying to prove that life can survive in even the most hellish of conditions. Countless microbes thrive in volcanoes, deep in ice sheets or in acid lakes – so there's no reason why a spark of life couldn't be hiding here, under the stones or between the grains of

sand of the Atacama's 'wet areas', which experience just a 50th of Death Valley's rainfall. And Chris McKay is using soup to prove it.

DO DESERTS VIOLATE THE LAWS OF EVOLUTION?

However, this is no ordinary soup. It's actually a nutritious molecule mixture made from sugar and amino acids – similar to what sustains all

How long can a desert live?

Nobody can say for sure how long the body was buried in the sand before a fisherman's dog recently dug it up. Perhaps 500 or even 1,000 years? Discoveries of mummies are not uncommon in the Chilean desert and virtually all of them are as perfectly preserved as this one: with their hair and clothing pretty much intact. Deserts halt a body's natural decay like no other landscape on Earth. In other areas it only takes a month for a corpse to turn into a skeleton. But the hot desert climate dries out the surface of the body, preventing the reabsorption of water. Bacteria that would otherwise cause tissue to rapidly decay can't penetrate the body. The organs are dissolved by their own enzymes and effectively digest themselves, leaving no trace.

The hunched posture of the body here was caused by its muscles shrinking as they dried. Everything lasts longer in the desert. And the desert outlasts everything. Scientists have now discovered that the Atacama desert is older than previously thought. Its age was revealed by its grains of sand, which absorb and save different levels of radiation from space over millions of years. Light analysis revealed that the driest desert in the world has barely changed over the past 25 million years.



creatures on Earth. All life consists of these substances. McKay uses a life-inhibiting soup as a counterbalance. It mirrors the protein components of the first concoction exactly, but in a form that does not exist on Earth. It's artificially created and is automatically rejected by life forms. So if there is no residue of the first soup left in the soil sample, it's evidence of life. If neither of the soups are touched, there's nothing currently living in the soil.

It's not impossible for something to establish itself here. But what

happened next took McKay completely by surprise: both samples disappeared. "That can only be proof of a radical chemical reaction," he says. Rather than being eaten by a living creature, it appears that the protein soups were simply destroyed by a process of oxidation in the ground itself. It's a unique occurrence: not only is life impossible in this 50-km stretch of the Atacama Desert, it is also simply unwanted. What's stored here, deep in the desert sand, is a kind of time capsule: it's nothing more than the

young, hot Earth of more than four billion years ago, before the first building blocks of life joined together in the oceans. A bone-dry world on the fringes of evolution.

Deserts cover a third of the planet – they're hostile, all-devouring, ever-enduring landscapes. They're not fragile ecosystems that would cease to exist with minimal intervention. Deserts last because they need nothing to survive – and as a result they conquer time. They accelerate, stop or even turn back the processes of birth and

Deserts and semi-deserts...

...cover about 50 million square kilometres. That's a third of Earth's landmass. They're characterised by the fact they contain little or no vegetation and their arid climate means they experience very little precipitation and extreme temperatures.

At 9.3 million square kilometres the Sahara is the largest desert in the world. But only a quarter of that is sand. The rest is mountains and vast areas of stone and gravel. The record for the largest desert composed purely of sand goes to Rub' al-Khali in the Arabian peninsular (650,000 square kilometres).

When it comes to temperature, the Gobi desert can get particularly chilly at minus 40 degrees Celsius, the coldest temperature recorded in a desert outside the polar regions.

The greatest threat to millions of people is 'desertification' – the destruction of vegetation,

soil erosion and storms – caused by global warming. In one year, winds can carry three billion tons of sand and dust across the planet.

More than a quarter of China's landmass is covered by deserts and they're growing by 210 square kilometres – every month! Experts say that trying to stop the deserts is like trying to stop time. Attempts to halt their growth have had little success. Recent plans, including one to construct a 6,000-kilometre wall made of bacteria and sand (the bacteria would bind sand grains together to form sandstone), and another to plant a giant barrier of trees at the Sahara's southern edge, only exist on paper. Any feasible project would also need countries to cooperate, but given the unstable political climate in the region, that seems unlikely. For now, then, the dream to halt the advance of the desert remains just that: a dream.



death. How? Through their smallest constituent parts: a grain of sand.

Researchers are mystified by sand as it exhibits many unexplainable physical properties. The scientific community believes its granularity may represent a fifth state of matter. Granular matter acts like a solid, a liquid, or a gas depending on the circumstance. "You walk on the beach, and the sand supports your weight," says physicist Heinrich Jaeger. "Pick up a handful, and it runs through your fingers, like a liquid. But you can't walk on water."

Sand's unique properties are indelibly linked with time: when, in the 14th century, someone first filled a slim glass with sand they created a simple and ingenious timepiece – the hourglass. The timepiece works because of the exchange of energy between the grains. If sand is very tightly packed, it forms curved

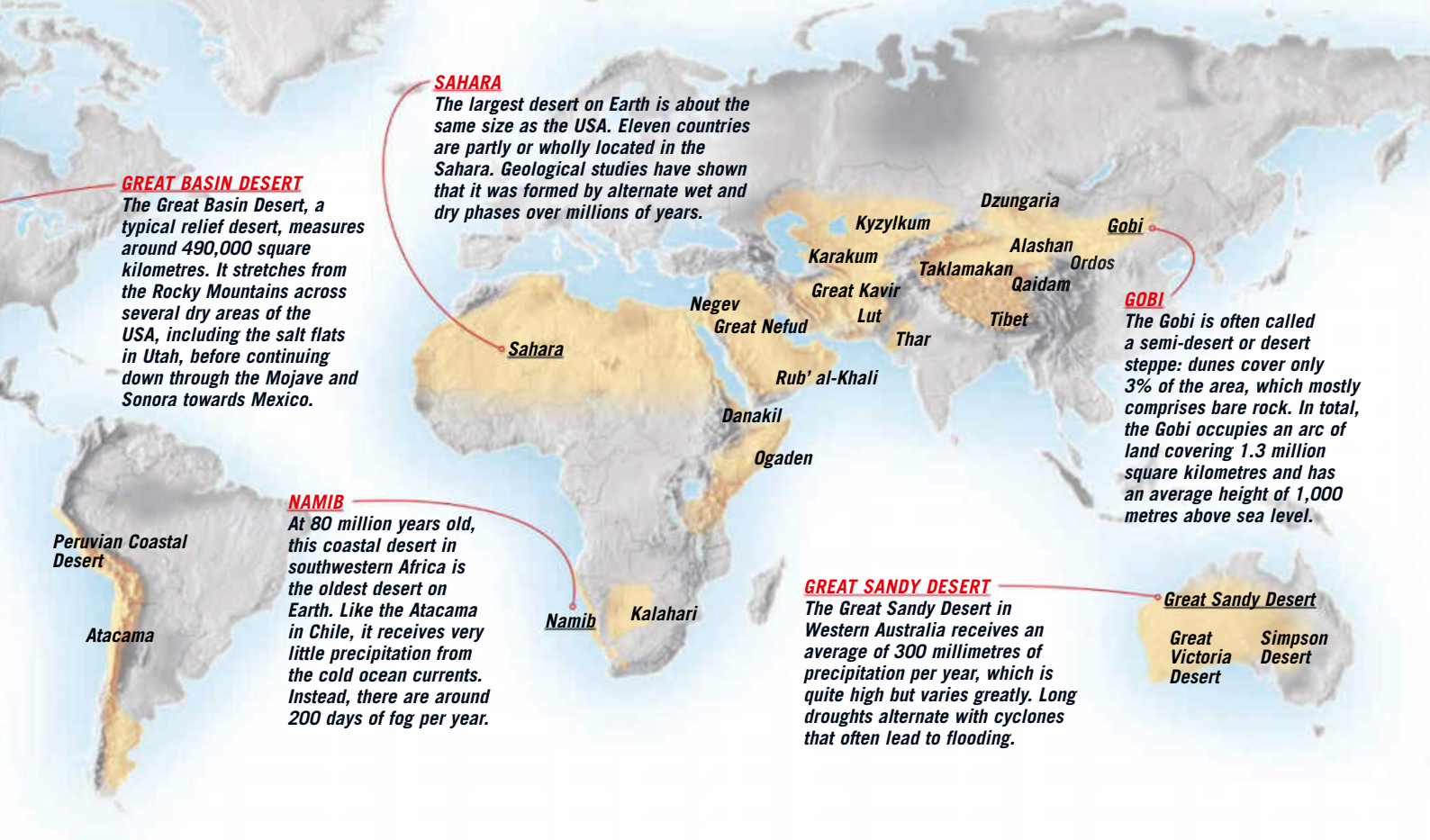
bridges with cavities in between. Like a towering Gothic cathedral, with a roof supported by arches, the force is distributed equally between every grain of sand. The same pressure always affects the sand at the middle of an hourglass – regardless of how much sand is above it. This means that the rate at which the grains trickle down always remains the same. It's the most accurate way to measure time.

CAN DESERTS CREATE A NEW BEGINNING FROM AN END?

A grain of sand is never around for long, but travels thousands of kilometres on the wind. In the

process, it carves away at the landscape like a flying sculptor. It's estimated that one billion grains are born in the world – every second. It's a beginning derived from an end: "The birth of a grain of sand signifies the death of a mountain," says British geologist and sand expert Michael Welland. Sand passes through a permanent cycle of erosion, transportation and deposition. As with a human fingerprint, a grain of sand's composition reveals its origin. Welland estimates that half of all sand has already been through the cycle six times.

A grain of sand is often joined to part of a rock through a special geological bonding process known as lithification, before being freed by the wind again – sometimes only after millennia. Gigantic formations like Monument Valley, which was once



a single plateau, are formed when layer after layer is stripped away, leaving behind the bizarre sculptures used as the backdrop to many Western films. Between Utah and Arizona sand acts like a gravedigger, shifting entire landscapes. A few hundred kilometres away, it even hides secret life itself.

Death Valley is the driest and most hostile desert in North America – nowhere else is the finality of all life so present that time seemingly ceases to exist. But researchers discovered something perplexing in its desert sand: despite ground temperatures of over 70 degrees Celsius, and despite its name, an orgy of life is dozing away here – billions of flower seeds that sprout at the same time, transforming the mouth of hell into a surreal paradise for a few weeks. The secret behind this mass blooming? A chemical

inhibitor inside the seeds, which lie inactive in the sand for over 30 years until they receive enough water to guarantee the survival of their flowers. The eggs of desert locusts are also kept in a dormant state for 20 years, after which a billion larvae hatch at once.

HOW DO PEOPLE LIVE IN THE DESERT?

But deserts don't just determine the timeline of plants and insects. In Tanzania's Great Rift Valley the Hadza people live just like their ancestors did 10,000 years ago. In fact, the whole of humanity can trace its roots back to the East African wilderness of 100,000 years ago. The Hadza grow no food, raise no livestock, and live without rules or calendars. Instead, they

live a hunter-gatherer existence with what the desert has to offer. And therein lies the secret of this ancient people: because the desert doesn't offer much, the Hadza have developed like no other group of people. Everyone has a cooking pot, water container and axe – conflict and warfare are rare. The desert has 'distributed' the Hadza people to places with water and game – the fact that tribes often live many kilometres apart means that they have never been seriously threatened or experienced an epidemic or famine.

It seems incredible that an ancient hunting people that has managed to survive into the 21st century, while most humans have been altering their climate and landscape, always developing more complex lifestyles. Turning back the wheel of time is impossible. Except in the desert. **w**

It's every pilot's nightmare: a criminal hacker taking control of the cockpit. But are aircraft really at risk from electronic attacks? And could an attacker actually control a plane from the ground?



CAN YOU HACK INTO AN AER



WI-FI GATEWAY

Modern planes already offer their passengers wireless internet. For hackers that's like being invited into the cockpit: at the airport they could infect the aircraft from the ground using malware.

OPLANE?

FROM CABIN TO COCKPIT

According to an FBI report, passenger Chris Roberts has already hacked into the electronics on a number of aeroplanes. On one flight the American IT expert and cyber-safety advisor even managed to alter the plane's course.



An attacker
can gradually take
control of the plane,
right up to the
engines.

A full-page photograph of a pilot in a cockpit. The pilot is wearing a white short-sleeved uniform shirt with epaulettes and a blue lanyard with an ID badge. He is holding a tablet computer in his right hand, which displays a flight map. The cockpit is filled with various instruments, including multiple digital displays on the left and center consoles, and a complex array of physical buttons and switches on the overhead panel. The background shows the blue sky through the cockpit windows.

AIRBORNE VIRUSES

Everyone connected to the internet has what's known as an IP address. This is how a computer can be identified within the network. The crew and passengers are connected to one another via a shared IP address. Several protective firewalls separate both systems – but just like every other software component, a firewall can't be considered totally infallible.

MALICIOUS APPS

Some airlines use laptops or tablets to communicate with their pilots. The captains receive flight paths or navigation information this way – it saves paper, but makes the aircraft more vulnerable. On 29th April 2015, flights operated by American Airlines were grounded because an app on these iPads had caused a software error.

HACKED POWER

The engines provide the necessary thrust to carry a plane into the air and keep it there. They're part of the plane's avionics, the collective noun for the electronic equipment fitted in an aircraft. On many modern aircraft these instruments are not physically separated from the inflight infotainment networks, giving hackers the opportunity to gain access to the cockpit as a result. According to the FBI, Chris Roberts [left] managed that on at least one occasion.

“F

ind myself aboard a Boeing 737. Shall we make the oxygen masks drop down? :)” That was the message Chris Roberts posted on Twitter during a flight on the 15th April this year – and it caused a storm. Because Roberts was not the pilot tweeting from the cockpit – he was a passenger in seat 3A. You can see why his tweet raised such a furore, because the person behind the username @Sidragon1 was not some joker, but the founder of the online security firm One World Labs.

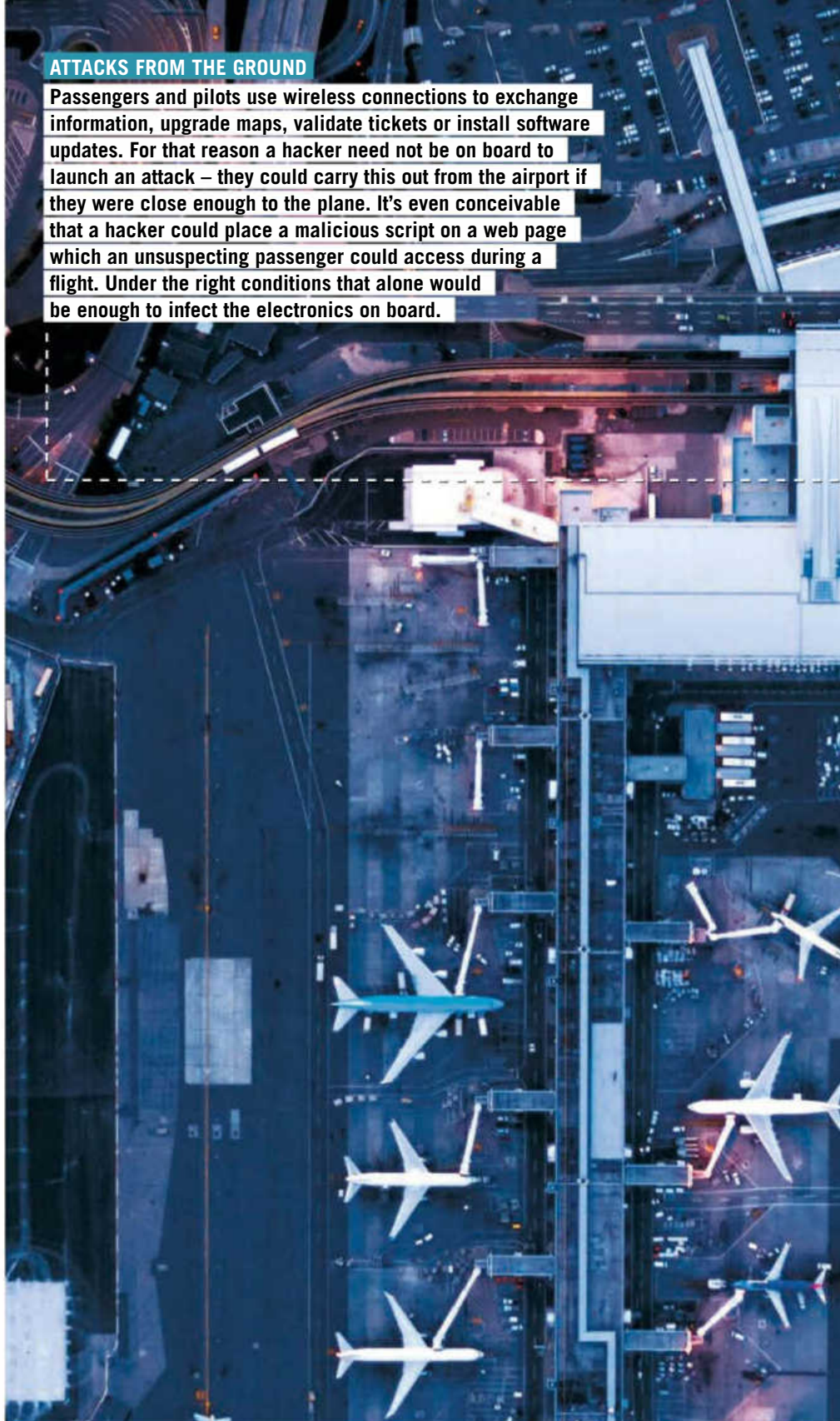
Roberts is considered one of the world’s leading experts on cyber-criminality and counts the US government among his clients. The FBI arrested him as soon as his flight touched down. What was behind the message? Had he really succeeded in hijacking the United Airlines flight from Denver to Chicago?

HOW DO YOU GET INTO THE COCKPIT USING JUST A CABLE?

Roberts allegedly used his laptop between 15 and 20 times to hack into commercial passenger planes

ATTACKS FROM THE GROUND

Passengers and pilots use wireless connections to exchange information, upgrade maps, validate tickets or install software updates. For that reason a hacker need not be on board to launch an attack – they could carry this out from the airport if they were close enough to the plane. It’s even conceivable that a hacker could place a malicious script on a web page which an unsuspecting passenger could access during a flight. Under the right conditions that alone would be enough to infect the electronics on board.



including Boeing 737s and Airbus A320s. In one case he was able to give the command to “climb” to the engine control and actually succeeded in changing the aircraft’s flight path – or at least that’s what is recorded in an FBI file. Roberts

used the in-flight entertainment network – a system that every passenger can access to watch films, play games or listen to music through – to gain access to the cockpit. It appears he got in by linking up his laptop to the seat



HOW DANGEROUS IS AN AIRPORT?



Even on the ground aeroplanes aren't completely safe: as recently as June 2015 an attack by a hacker on the Polish airline LOT grounded the company's planes at Warsaw airport for five hours. A dozen flights had to be cancelled. The problem: pilots must constantly update the software and latest information on their aeroplane – regardless of whether they're currently flying in Australia, Japan or Zimbabwe. Even though the classic method of hijacking an aeroplane is becoming more difficult, the danger of hacker attacks is rising. In a study by Allianz, cyber attacks came in at number 8 on the list of risks.

DIGITAL BOMBS

Every passenger must pass through a security scanner before boarding. But the alarm is only set off by bombs and explosives, not by bits or bytes. IT expert Chris Roberts succeeded in smuggling a whole arsenal of digital bombs stored on USB sticks, laptops and tablets on board various planes belonging to one airline. The company banned him as a safety precaution.

FALSIFIED COMMUNICATION

ACARS is an automated communication system between air traffic control on the ground and the cockpit. The messages exchanged are unencrypted – so a hacker could manipulate the flow of data. In a simulated exercise attackers succeeded in feeding the autopilot of a plane false information over ACARS, setting it on a collision course.

electronic boxes (SEB), which are installed under the airline seats. An FBI agent later found “signs of sabotage” there. Roberts’ job is to penetrate protected computer networks for testing purposes. At the time of the ‘crime’ he was

also carrying details of the electronics on other types of planes as well as malware. Soon after the incident the FBI and US transport authorities issued an official warning about aeroplane hackers to commercial airlines.

COULD A SMARTPHONE APP BRING DOWN AN AIRPLANE?

So far no attacker has succeeded in hacking an entire plane. But have they come close? “On new planes there’s a whole range of potential



gateways that hackers could use to invade the system,” explains Hugo Teso, a pilot and IT expert in flight security.

In simulated conditions he showed how a smartphone app (we have intentionally not named it) could program the autopilot of a commercial aircraft onto a collision course. Straight-out-of-the-factory planes are usually pretty robust, says Teso, but upgrades make them targets for attack: more and more airlines are offering their customers access to Wi-Fi on board new planes like the Boeing 787 or the Airbus A350. The network that passengers use to surf the internet is the same one that pilots use to control the plane – a firewall is often the only thing separating the two. This cuts costs for airlines because instead of every onboard instrument working in isolation, as previously, different devices now share the same computer. This concept is known as Integrated Modular Avionics and saves a ton of weight and therefore fuel.

Computer systems that aren’t physically separated from one another are always vulnerable – and as airlines switch to internet-based networks, it’s not uncommon for



HACKER HUNTER

From his office in Milwaukee, Wisconsin, Alex Holden monitors around 800 online black markets around the world.

Wi-Fi systems to share routers or internal wiring. “When I’m able to deceive a device, I can actually gain access to the controls over restricted areas,” explains Dr Jon Haass, head of Cyber Security at Embry-Riddle Aeronautical University in Arizona.

On average pilots only control the aircraft manually for between four and seven minutes.

Meanwhile, a report by the US Government Accountability Office warned that a “virus or malware planted in websites visited by passengers could provide an opportunity for a malicious attacker to access the IP-connected onboard information system through their infected machines.” Meaning a hijack could be led from the ground – or a terrorist with a laptop could sit among the passengers and take control of the plane using its Wi-Fi.

CAN I BUY AEROPLANE HACKS?



Alex Holden’s job is to hunt criminal hackers – and he excels at it. He counts airlines among his clients as hacking attacks against their frequent flyer programs are very common and profitable. But that’s small fry: someone offering a way to hack into a passenger plane could command top dollar on one of the dark web’s marketplaces. In comparison, the black market price for a hack into Apple’s iOS mobile operating system is up to \$500,000.

DOES THE ONBOARD COMPUTER HAVE A RESET BUTTON?

So far airline companies, manufacturers and various governmental agencies for IT safety have played down the issue in public: “Even a successful attack would only be able to confuse the pilot. It couldn’t take control of the entire plane,” said one IT safety agency. But is that really true? To deny criminal hackers any advantage, outsiders aren’t given any insight into how cyber-security measures on board actually function. US security expert Bruce Schneier says that “while remotely hacking the 787 Dreamliner’s avionics might be well beyond the capabilities of anyone except Boeing engineers today, that’s not going to be true forever.” Reliance on technology is only increasing, as are opportunities for hackers: some pilots already receive important communications through an iPad. In April of this year, American Airlines planes could not take off because of a software error on these devices.

Also this year it was revealed that the onboard computer of an Airbus A321 bound for Munich had sent the aircraft into a downward plunge. Only by carrying out an emergency reset of the computer were the pilots able to bring the plane back under control. For the crew this technical glitch culminated in the ultimate nightmare: they pulled the aircraft upwards – but the computer kept directing it towards the ground. Miraculously, nobody was harmed.

Cockpit computers are gaining in power: this year the Pentagon will carry out the first test flights with a robot instead of the co-pilot – the military hope this will be the future of civil aviation. For now crew can still disable commands given by onboard software. But the first fully automatic cargo planes are already being developed. For criminal hackers, that’s wonderful news. 

PHOTOS: Shutterstock; Karim Nafatni; Getty Images; PA; PR; wdw (3)

SMARTER IN 60 SECONDS...

4 FASCINATING QUESTIONS ABOUT FLIGHT SECURITY

HOW MUCH DOES AIRPORT SECURITY COST AUSTRALIA?



A 2011 Productivity Commission report estimated that airport security charges were around \$20 for a return trip. When you factor in the extra time wasted by every traveller (57 million domestic passengers, and 34 million international ones), you're looking at a cost to the community of at least \$2 billion every year. Money well spent? In the US at least, research suggests it's not. An ABC news investigation revealed that airport screening in America failed to detect 67 out of 70 mock smuggling operations.

Can anything protect a plane from a bomb?



Scientists, including a team from the UK's University of Sheffield, have found a new way to protect passengers by protecting the plane itself. The 'FlyBag' is a bombproof membrane designed to line the plane's hold. Fundamental to the design of the bag is a combination of fabrics and composites, including Kevlar (which is used in bulletproof vests), that have high strength and impact and heat resistance. Tests have shown that the luggage hold may be able to contain the force of an explosion should a device concealed within a passenger's luggage be detonated during a flight. This would mitigate damage to the plane and help keep passengers safe. "Key to the concept is that the lining is flexible," says team member Andy Tyas. "This helps to ensure that the Fly-Bag acts as a membrane rather than as a rigid-walled container which might shatter on impact."

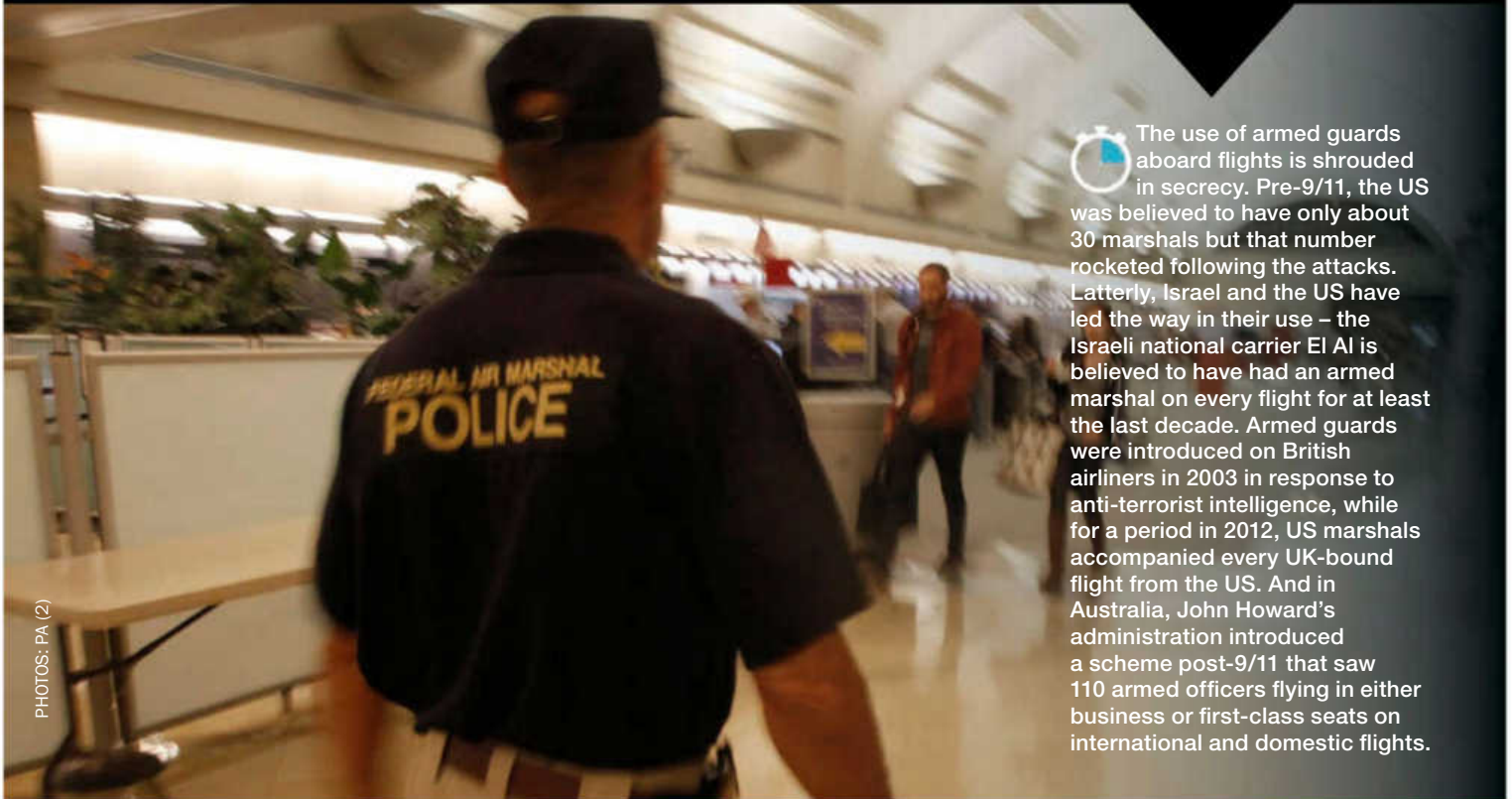


How do full-body security scanners work?



Designed to be an upgrade to the 'pat down' searches carried out at airports, most scanners today use millimetre wave imaging technology. Instead of using x-ray beams, they work by bouncing electromagnetic waves off an individual's skin to produce an outline image of the body, showing any concealed objects. Images taken are analysed digitally within the equipment – the image of the passenger is never seen or stored. In a further nod to passenger privacy, the scanner displays an indication of possible threat areas on a generic 'gingerbread man' image, rather than the actual image of the person's body.

DO AIR MARSHALS ROUTINELY PATROL THE SKIES?



The use of armed guards aboard flights is shrouded in secrecy. Pre-9/11, the US was believed to have only about 30 marshals but that number rocketed following the attacks. Latterly, Israel and the US have led the way in their use – the Israeli national carrier El Al is believed to have had an armed marshal on every flight for at least the last decade. Armed guards were introduced on British airliners in 2003 in response to anti-terrorist intelligence, while for a period in 2012, US marshals accompanied every UK-bound flight from the US. And in Australia, John Howard's administration introduced a scheme post-9/11 that saw 110 armed officers flying in either business or first-class seats on international and domestic flights.

They criss-cross countries like gigantic spiders' webs and supply us with that most important commodity: power. But how do you maintain pylons and power lines? We look at the dangerous work of high-voltage electricians

500,000

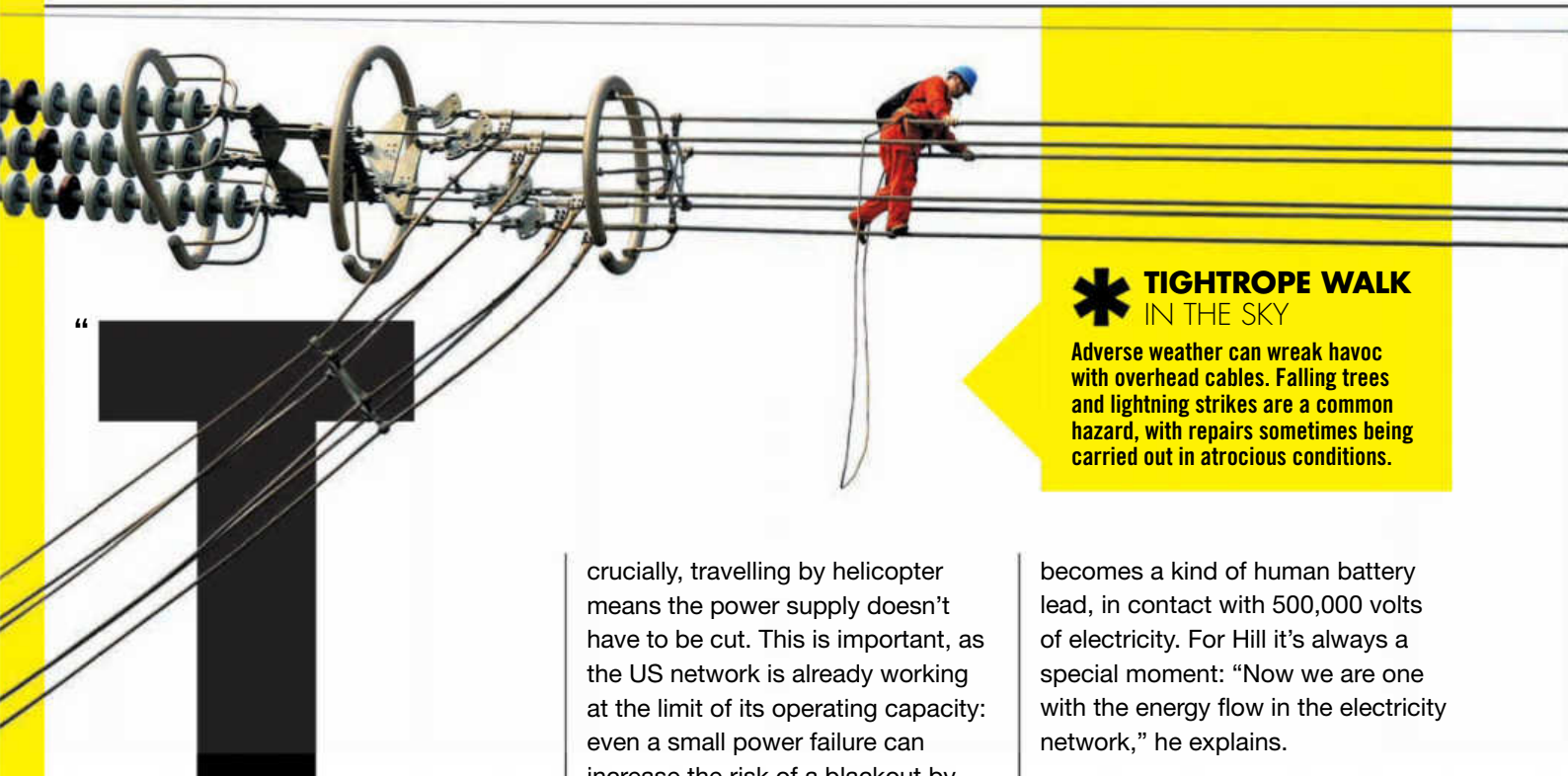


BALANCING ACT

Just a few millimetres of suit separate this cable repair engineer from the power lines – he's perched on half a million volts. But current needs a conductor to flow: things only get dangerous if the engineer were to accidentally touch a pylon. Then the contact is closed – and a huge electric shock would burn his body...

0 VOLTS

ARE THREATENING THIS MAN'S BODY



“

he power lines are live – half a million volts. We’re flying towards them in this big old metal helicopter of ours, and we’ve got a full tank of fuel right beneath us. We’re about to become part of the electrical circuit. I can feel the vibrations in my hands, hear the buzzing and crackling of the electricity...”

Anyone listening to Ryan Hill or watching him work would think he had a death wish. For while others usually keep well away from high-voltage power lines, Hill and his colleagues get in a helicopter and head straight for them. This is the most efficient way: ground missions take longer, cost twice as much and,

crucially, travelling by helicopter means the power supply doesn’t have to be cut. This is important, as the US network is already working at the limit of its operating capacity: even a small power failure can increase the risk of a blackout by overloading the alternative flow route.

High-voltage electricians like Ryan Hill know their responsibilities – every day they risk their lives to maintain the national power supply. Travelling by helicopter allows Hill to reach far-flung problem areas much faster than if he travelled by car, and also saves him a long, arduous climb.

Like an oversized bumblebee, the helicopter buzzes between the 50-metre-high pylons. When he’s ready to start work, the first thing the mechanic does is equalise his voltage with the line by placing a conducting rod between the cable and the helicopter. This brings him onto the same voltage level – he

* TIGHTROPE WALK IN THE SKY

Adverse weather can wreak havoc with overhead cables. Falling trees and lightning strikes are a common hazard, with repairs sometimes being carried out in atrocious conditions.

becomes a kind of human battery lead, in contact with 500,000 volts of electricity. For Hill it’s always a special moment: “Now we are one with the energy flow in the electricity network,” he explains.

THE DANGER FLOWS DIRECTLY OVER THE SKIN

An electrical energy charge of just 50 volts can penetrate a person’s skin. The cables carry 10,000 times that amount – and only a millimetre-thick layer of metal protects Hill from certain death: it is found inside his protective suit, which comprises 75% fireproof Nomex fibres and 25% rust-free stainless steel mesh. As a result, the substance does not insulate, but rather reroutes the electricity around Hill’s body like a Faraday cage – the same way the body of a car does if the roof is struck by lightning. This physical trick allows Ryan Hill to climb



MORE THAN 725,000 KILOMETRES is the distance covered by the USA’s high-voltage power network. Maintenance crews reach far-flung places by helicopter.



USING A CONDUCTING ROD the technician equalises the voltage levels between the power line and the helicopter before climbing out.



FROM THE WORKING PLATFORM of the helicopter, the mechanic moves onto the power line. During the process, more voltage-equalising takes place.

100 METRES HIGH

BLACKOUT

In the US a disconnection is only carried out in an emergency: if the electricity has to flow via alternative routes, the ailing power network risks total failure. That's why their technicians have to climb on power lines that are switched on.

INSULATORS

To avoid electricity flowing off the masts and the pylons becoming live, the cables are attached to insulators made from glass, porcelain or plastic. Their ribbed design also creates an obstacle to the electrical flow.

AIR TRAVEL HAZARD

Any electricity pylons over 100 metres in height are generally considered an aviation hazard.

around comfortably on the power lines – as long as he keeps his distance from neighbouring cables. Neither the pylon nor a leaf from a nearby tree are allowed to come into contact with him or the helicopter. If they did, the impact would be fatal because an electric circuit would form between the cable and the ground. The biggest threat is

therefore the wind, which blows twice as hard 50 metres up as it does at ground level. For this reason, the team only works when the wind speed is less than 50 kilometres per hour, otherwise they wouldn't be able to keep the helicopter under control. But in this job you only make one mistake – your first is usually your last. 

* A BOLT OF LIGHTNING SHOOTS THROUGH EVERY POWER LINE. A SINGLE ERROR COULD SPARK A 10,000-DEGREE INFERNO

When building a new network, engineers must prepare the cable for dealing with enormous amounts of energy. Almost half the amount of electricity contained in a lightning bolt flows through the cables – not just for milliseconds, but continually. The cables are made of steel and aluminium and are just a few centimetres thick. If a human were to bridge the voltage difference between the power line (up to 500,000 volts) and the mast (0 volts), their body would be frazzled in an instant by a temperature of 10,000 degrees Celsius. Unlike ground cables, overhead power lines are only insulated by the air.

THE LIFESAVER

for every power line worker is their protective suit. The electricity flows around it, and along the body, rather than through it.

THE FINAL CONTACT

that the mechanic has after returning to the helicopter is always with the compensating cable. It is the last thing to be removed.

An aerial photograph of the Burj Khalifa in Dubai, showing the tower's distinctive Y-shaped structure and its reflection in the surrounding urban landscape. A white line with a small square at the end points from a callout box to a specific section of the tower's facade.

WHAT WIND SPEEDS CAN THE BURJ KHALIFA WITHSTAND?

At a height of 828 metres, the hot, dry winds known as shamals that blow across the Persian Gulf can reach speeds of over 160km/h. But thanks to its aerodynamic shape the mega-tower provides only a very small target area – wind is deflected around the building. In spite of this the building still sways back and forth by several metres at the very top.

THE BURJ KHALIFA IN DUBAI

HOW SAFE IS THE TALLEST BUILDING IN THE WORLD?

828 metres high, weighing 500,000 tons, construction costs of about \$2 billion – the Burj Khalifa trades in superlatives. But did the architects spare a thought to the extreme forces the tower would be subjected to when they were building it?

DO YOU HAVE A QUESTION FOR OUR TEAM OF EXPERTS?

Simply send us an email with 'Questions and Answers' in the subject line to worldofknowledge@bauer-media.com.au

WHAT IF THERE'S A FIRE?

The 57 elevators race to the 189th floor (638 metres up) at a speed of ten metres per second. The building service and fire elevator serves all levels up to the 136th floor (504 metres up) and can be used in an emergency. There are also pressurised, air-conditioned refuge areas located every 25 floors that can withstand fires for up to four hours.

HOW DOES THE TOWER DEFEND ITSELF AGAINST A TERRORIST ATTACK?

Barriers at street level can stop a vehicle weighing up to 7.5 tons and travelling at 80km/h. Inside the building sensor gates and turnstiles ensure that nobody without authorisation can enter the building.

HOW FAR DOWN DOES THE GIANT PIERCE THE SOIL?

Officially the Burj Khalifa is 828 metres high – but in reality it is markedly taller because of its 192 concrete piles (each is 1.5 metres in diameter) that are buried 50 metres into the ground. As a result the skyscraper can withstand earthquakes with a strength of 5.9 on the Richter scale.

100 km – that's how far away the spire can be seen

Construction cost around \$2 billion

330,000 cubic metres of concrete were required

22 million man-hours were spent building the structure

28,000 glass panes surround the high-rise facade

10°C colder at the top than at ground level

3,000 stairs lead from the ground to the top

2.93 EIFFEL TOWERS would have to be piled on top of one another to reach the Burj's highest point

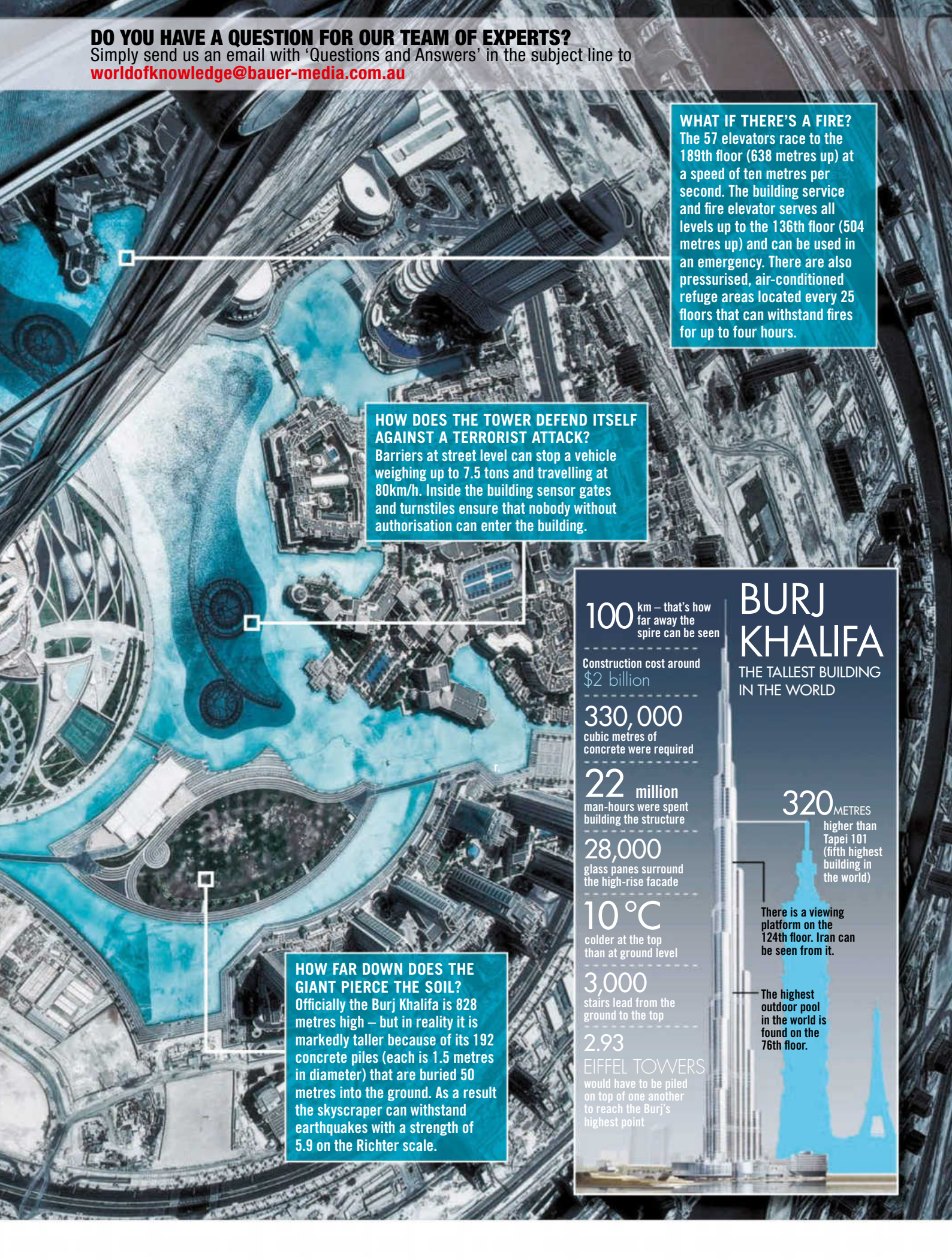
BURJ KHALIFA

THE TALLEST BUILDING IN THE WORLD

320 METRES higher than Taipei 101 (fifth highest building in the world)

There is a viewing platform on the 124th floor. Iran can be seen from it.

The highest outdoor pool in the world is found on the 76th floor.





WHAT MAKES THE JUNGLE GLOW AT NIGHT?

It's actually one of the darkest places on Earth. But despite this, some parts of Brazil's Pantanal wetland – a protected nature reserve 10 times the size of Melbourne – are so brightly lit-up at night that you'd be able to read a book there. The reason: green termite hills, some of which can reach eight metres in height. But it's not the termites that are responsible for this nightly light show, but rather the larval form of the Brazilian click beetle. The larvae are found in small holes in the outer walls of the mounds, where they sit with their glowing heads sticking out. Their greenish glow seems to have one function – to attract prey. Because they would be hard to spot in

high grass, they colonise the termite hills instead. The source of their light is one of the most ingenious inventions in nature: bioluminescence. Their light power is enormous and extremely efficient as well. The larvae use a chemical process to gain energy: an enzyme, luciferase, ensures that an endogenous chemical compound, luciferin, reacts with oxygen. In the process energy is freely released in the form of photons (light particles). The light efficacy lies at around the same level as modern LED bulbs. Like LEDs the larvae also produce "cold light" – emitting up to 10,000 times less chemically generated energy in the form of heat than a lightbulb.

GUEST WORKERS OR ILLEGAL IMMIGRANTS?

Researchers are at odds over whether the termites welcome the luminescent beetle larvae, or simply tolerate them. Most are of the opinion that the termites can't do anything to stop them: they have no chance against the ravenous larvae that set up home in the mound's walls. But it's not all bad news for the termites: some of their predators (like ants) are on the larvae's menu.

THE RAIN BRINGS THE LIGHT

The termite mounds only light up for a few days each year – immediately following the first downpours of the rainy season. Photographer Ary Bassous spent almost a decade trying to capture this magical moment but only succeeded last year. "I was scared of jaguars and other dangerous animals, but it was worth it," says Bassous.

ELABORATE STREET NETWORK

Beneath the glowing green facades of the termite mounds, invisible highways connect the individual hills. But a pair of eyes cannot see these termite roads. They are made of invisible pheromone trails – complex scent codes that govern traffic, closing off routes or pointing the termites in the right direction.

WHO LEFT THE LIGHTS ON?

Looking at the illuminated mounds, you'd be forgiven for thinking that termites like to leave the lights on at night. But that's deceiving. Termites are blind. The light comes from the larvae of click beetles that live in small burrows in the outer walls of termite mounds.

WHY ARE MEN STRUCK BY LIGHTNING MORE OFTEN THAN WOMEN?

According to statistics 79 people die every year as a result of a lightning strike in the USA alone. Between 1968 and 2010 a total of 3,389 deadly cases were recorded. The remarkable thing? 85% were men. One study has suggested a possible explanation for the reasons behind this: between 2006 and 2012 most fatalities occurred while the victim was fishing (26), followed by camping, playing football or golf – all hobbies that are generally more popular with men. According to the study many people underestimated the danger of these outdoor activities and didn't allow enough time to get themselves to safety.

STORMY WEATHER

Around 3,000 storms are raging somewhere in the world at any one time, while over 100 lightning bolts crackle through the air every second. Only 30% of people who are struck by lightning actually die.

WHICH GAS IS FLOWING OUT OF THIS OPENING?

What smells sweet, has healing properties, can prevent moths from eating your clothes and can be used in various recipes? The answer is lavender, a real multi-purpose weapon. But where does its unmistakable fragrance come from? An electron microscope provides the answer: small narrow openings on the underside of the plant's leaves. Known as stomata, they regulate the release of gas. However, they only produce the complex scents when it will benefit the plant, using them to attract bees and ensuring the pollination of the flowers.

WHAT DANGERS ARE LURKING IN MY LOCAL SWIMMING POOL?



GERM BREEDING GROUND

According to a US study up to 20 gastric bug and diarrhoea epidemics per year are the result of contaminated swimming pools. Children's pools are the perfect breeding ground for thousands of dangerous germs, in spite of the chlorinated water. Even adult visitors bring with them around 140 milligrams of faeces and up to 1.6 milligrams of urine.

THE WRONG STROKE

As well as being the oldest known stroke, the breaststroke is also the most popular. Hardly surprising as it helps strengthen the muscles and preserve our joints. The problem: experts say more than half of us have the wrong technique and are placing undue strain on our neck vertebrae and knee joints as a result. The most common error is keeping the head above the water. This stiff position leads to tension in the neck and can cause back pain.

BEWARE THE BELLYFLOP

An adult weighing 80kg jumping into a pool from a height of ten metres reaches a speed of 50km/h and displaces up to 75 litres of water in one dive. If they hit the water on their stomach or back, the water can have the effect of being as hard as concrete. This is because the larger the surface area of the body hitting the water, the larger the resistance force of the water pushing back will be. Possible consequences: bruises, burst eardrums – even broken bones.

TOP 10

ANIMALS WITH THE FASTEST HEART RATES



Pygmy shrew (1,500 beats per minute)

Its heart weighs 0.035 grams – huge relative to its body weight of just 6 grams.



Hummingbird (1,260)

At night the hummingbird's heartbeat falls to just 20 beats per minute to save energy.



Canary (1,020)

Its heart rate and blood flow are so high that the bird uses more energy than an elephant when body weight is taken into account.



Rat (420)

The rat's heart works so efficiently that researchers recently succeeded in siphoning off 0.12 microwatts using nano-cables.



Rabbit (205)

A rabbit's heart pumps blood around its body at four times the speed that a human's blood flows through its arteries.



Giraffe (170)

Giraffes don't only have the highest blood pressure. They also have a heart that weighs 12kg.



Spider (138)

Their lower abdomen contains not just their gut, silk glands and breathing organs, but also their heart.



Cat (130)

A cat's heart weighs 25 grams and beats more than 350 million times during its average lifetime of 13 years.



Zebra fish (120)

In contrast to all other known vertebrates, zebra fish can regrow destroyed heart tissue.



Dog (95)

The dog's heart beats irregularly – when inhaling the heart rate is higher, when exhaling it is lower.

*Humans are close behind at number 11 with 72 beats per minute. Our hearts beat almost a billion times during our lifetimes.

CAN A HELMET PROTECT ME FROM FAINTING?

Fighter jet pilots are permanently subjected to extreme forces in the air. It's not uncommon for them to lose consciousness during flights because their brains are not supplied with enough blood and oxygen. That could lead to a worst-case scenario – a crash. To prevent this an Israeli firm has developed two sensors which continually monitor the pilot's condition. Mounted in the helmet, the sensors measure the pulse, blood pressure and oxygen content of the blood. Should a critical situation occur, a warning appears on the helmet display, which is integrated into the visor. If the pilot loses consciousness, a signal is sent to the on-board computer which then automatically activates the autopilot. Cost per helmet: \$400,000. 



World of
Knowledge *AND FINALLY...*





I BELIEVE *I CAN FLY!*

Owls would gladly skip this phase of their lives if they could. Their haphazard flying skills mean they have to hop to get around – and that’s just plain embarrassing

You’ve laboriously squirmed your way out of the nest box and gained some distance from your annoying siblings – now what? You sit idly on a branch because you haven’t quite mastered how those feathery things on the right and left of your body work. Birds like this young Little Owl are called fledglings – too young to fly properly, but bursting with determination to show the world just what they’re capable of.

Initially that’s just the ability to hop furiously from branch to branch. Can it already feed itself? Not yet – mum still needs to bring it food. The fledgling bird lets its parents know where it’s scampering about by letting out a loud chirping noise. Since this noise can be up to 300 metres away, the chirping is basically their

way of saying: “Defenceless ball of fluff waiting for predators!” Unfortunately, the fledgling only has one defence mechanism in dangerous situations: to sit still and try to blend in with its surroundings.

Understandably, it doesn’t always work. But, if the camouflage is successful, the owlet must spend up to four weeks between the tree and freedom, which is enough time to perfect its climbing skills.

No incline is too steep for its little claws. According to studies, an owl’s parents encourage their offspring to take to the skies by calling to it while it’s scrambling. And really, is there a more noble sight than an owl spreading its wings for the first time, gliding off from a steep rock or treetop and conquering its own territory? It’s well worth waiting for. **W**

LETTERS

*Letters may be edited for publication

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Next issue
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Something in the air

SIMON LEWIS

I found 'Drone vs. Drone' (October) completely fascinating – and frightening. I'd never really considered the danger drones pose to commercial aircraft before reading the article. I've since read that a technology known as 'geo-fencing' could be used to prevent drones from entering certain areas where they could cause harm.

> *Quite right – geo-fencing utilises the GPS installed on drones. The software can be programed with the coordinates of thousands of airports around the world and can prevent a drone from flying into these areas. An unmanned aerial vehicle attempting to fly within the restricted area would be forced to land. The technology can also be used to cap the flying altitude of drones to ten metres when close to large airports. The British Airline Pilots Association (BALPA) is currently campaigning for geo-fencing technology to be installed on all drones before sale. One Chinese drone manufacturer, DJI, has already implemented the technology.*

Out of season

GAIL EVANS

I enjoy the articles about the human body in *World of Knowledge*. The recent feature '100 Facts You Should Know About Your Body' (Special Edition) was a favourite in our household. We wondered if you could clear up a myth for us – I love coriander but my son and partner insist that it tastes like soap. Is this dislike genetic?

> *Your family are in good company, as coriander has historically been one of the most divisive of herbs – even acclaimed chef Julia Child confessed to hating the green seasoning. This may have been hard-wired in her DNA: recent studies established a link between distaste for coriander and olfactory genes. Researchers pinpointed most coriander-phobes as those with a shared cluster of smell and taste genes that are especially sensitive to a group of chemicals found in both coriander and soap. Between 4 and 14 per cent of the world's population are thought to be affected by this genetic quirk. Crushing coriander instead of chopping it may reduce the soapy taste as the offending chemicals break down more quickly.*

Troubled waters

PETER GESUNDA

I read your article about the expansion of the Panama Canal ('The Biggest Building Site In The World', October) with interest. I also heard that a similar canal is going to be built in Nicaragua. Is this true?

> *Building work on the proposed 260-km canal between the Atlantic and the Pacific has already begun in Nicaragua. The \$50 billion project is being part funded by the Chinese company HKND, with Nicaragua paying the other half. But critics doubt that the mega-project will ever be successfully completed in light of its ambitious dimensions and environmental concerns.*

Burning bright

LINDA FREEMAN

This year was the first I was able to observe the annual Perseid meteor shower – while I was on holiday in the UK. The show of shooting stars was as spectacular as I hoped it would be, but I realised afterwards that I don't know why it occurs. Could you shed some light on the origins of the Perseid shower?

> *Every year Earth crosses the orbital path of a comet known as 109P/ Swift-Tuttle. This comet is the parent of the annual Perseid meteor shower, which peaks in mid-August. When comets pass by the sun, they shed particles of dust, ice and rock. These cosmic leftovers gradually congregate in a dusty tail around each comet's orbit. Swift-Tuttle's path is close enough to our planet that these particles are swept up by Earth's gravitational field. When they collide with our atmosphere the pieces of dust and rock burn up, appearing as radiant streaks of light in the night sky. The shower is so named because it appears to radiate from the constellation Perseus. The meteors, often called shooting stars, travel at a speed of around 210,000km/h. During the shower's peak, the rate of meteors reaches 60 or more per hour. Despite each rock being roughly the size of a grain of sand, most can be seen with the naked eye.*

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ADVERTISING ENQUIRIES:

BRAND MANAGER
Sarah Lattouf
EMAIL:

SLattouf@bauer-media.com.au
PHONE:
02 8114 6021

INTERNATIONAL EDITOR-IN-CHIEF

Uwe Bokelmann
INTERNATIONAL EXECUTIVE EDITOR
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INTERNATIONAL CREATIVE DIRECTOR
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MEDIA GROUP

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The Whitsundays

74 Island Wonders

In the heart of the Great Barrier Reef



Hill Inlet, Whitsunday Island, The Whitsundays

In the heart of Queensland's Great Barrier Reef lies The Whitsundays, a place of stunning natural beauty and breathtaking experiences.

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